NAVSHIPS 0967-133-7010
(Formerly 95706)

TECHNICAL MANUAL
for
OSCILLOSCOPE
AN/USM-140B
and
AN/USM-141A

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS

TEMPORARY CORRECTION T-2 TO THE TECHNICAL MANUAL FOR OSCILLOSCOPE AN/USM-140B, AN/USM-141A, NAVSHIPS 95706.

The purpose of this temporary correction is to correct minor errors in NAVSHIPS 95706 dated 20 May 1964 which were not covered in temporary correction page T-1, and to indicate changes in model numbers of certain items of the AN/USM-140B equipment. Insert this sheet in the manual immediately behind the front cover.

Make the following pen-and-ink corrections in the text of the manual.

PAGE NO.	ACTION
v, vi, vii, 1-0, 1-3, 1-6, 1-7, 2-3, 3-11, 4-1, 4-2, 4-3, 6-1, 6-2, 6-26, i-2, i-4	Where applicable, change: "CW-511/USM-105" to "CW-511A/USM"; "MX-3078/USM" to "MX-3078A/USM"; "MX-2817/U" to "MX-2817A/U"; "MX-2962/USM" to "MX-2962B/USM"; add the suffix "A" after "AN/USM-141".
2-2	In Figure 2-2, change "1-1/2" to "2-3/8", "19-3/4" to "18-3/8".
5-17	After para 5-5a, add "An unused replacement 7308 tube may exhibit a stabilizing action for about twenty-four hours of operation after it is first placed in service. Tubes which have been "aged" at normal operating conditions for this period of time can be used for replacement if it is necessary to avoid a change in tube characteristics during this short breakin period. The V508 position in the MX-2930B/USM Dual Trace Premaplifier is sensitive in this respect and aged tubes are recommended for replacement use in this position.
5-25	In Figure 5-10, change "C405" to "L405".
5-26	In Figure 5-11, add callout "R270" to resistor directly above C408.
5-27	In Figure 5-13, change SWEEP OUTPUT to "J104".
5-67	In Figure 5-41, change ground on R258 to "-100V".
5-71	In Figure 5-43, at connector marked MILLIVOLTS add "J301".
5-73	In Figure 5-44, change R437 to "2K".
5-80	In Figure 5-48, below J105 change "166" to "horizontal channel"; below J1 change "162" to "vertical channel".

TEMPORARY CORRECTION T-1 TO THE TECHNICAL MANUAL FOR OSCILLOSCOPE AN/USM-140B, AN/USM-141A, NAVSHIPS 95706.

The purpose of this temporary correction is to correct minor errors in the text of NAVSHIPS 95706 dated 24 March 1964. Insert this sheet in the manual immediately behind the front cover.

Make the following pen-and-ink corrections in the text of the manual.

PAGE NO.	ACTION
iii	After paragraph 2-4, add suffix "A" after "AN/USM-141"
v	After figure 2-0, change "Supply" to "Shipping"; after figure 2-3, add suffix "A" to "AN/USM-141".
4-4	In running foot, change "ORIGIANL" to "ORIGINAL".
4-7	In third paragraph, second line, delete "all"; in last paragraph, ninth line, delete "DC".
4-9	In step 6 RESULTS, add "C425" after "L506"; add line across chart between steps 7 and 8.
4-13	At test points A11 and A18 change arrow to point to "C"; in voltage chart, change A6-A9 voltage from "3" to "10".
4-17	In table 4-4, steps 14, 15, 16 add "Remove V301 and" before "Measure ..."
4-33	In figure 4-9 add test point "C19, +41 v, 40v p-p" at junction of C213 and C214.
5-39	On etched circuits, for XV206, interchange the tube pin numbers "1" and "9".
5-41	On etched circuits, change "R227" to "R277"; in 5-24 caption, change "Previews" to "Preamp".
5-46	In Parts Location Index, delete C413; add "R429, D5" and "R437, B5".
5-59	Change value of R88 to "47K".
5-63	Change "R105" to "R1012".
5-67	In diagram and index change "R227" to R277".
5-77	Change value of C1507 to 10; change value of R591 and R592 to 1200; change value of R570 to 3900; in the transistor connection diagram, interchange "E" and "C".
6-1	Add "Table 6-1" before "List of Tables".
6-2	In A202 P/N change "R" to "L".
6-3	After "A403, POWER CABLE:" Add "CX-4704/U 8' 0" ".
6-4	For CR416, change "CR403" to "CR103".
6-5	For C212, change "Fixed Air" to "Adjustable, ceramic: 0-1 pf, sleeve on resistor body."
6-6	For C413 delete description and add "Same as C1".
6-9	For Q406 delete "Same as Q401" and add "JAN type 2N1309"; For Q410 delete "JAN type 2N1309" and add "Same as Q406"; For Q411 change "Same as Q410" to "Same as Q406".
6-13	Delete "R227"; "R277 RESISTOR: Same as R1".
6-17	For W401 change "CX-4704/U" to C0-03LGF(3/18)0206".
6-24	For R591 change "RC20GF182K" to "RC20GF122K".

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TECHNICAL MANUAL

for

OSCILLOSCOPE AN/USM-140B AN/USM-140D

and

AN/USM-141A

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS

Approved by BuShips: 24 March 1964
Change 1: 21 April 1965

LIST OF EFFECTIVE PAGES

PAGE NUMBERS	CHANGE IN EFFECT	PAGE NUMBERS	CHANGE IN EFFECT
Title Page	Change 1	2-3 to 2-4	Original
ii	Change 1	3-1 to 3-12	Original
iii to vii	Original	4-1 to 4-54	Original
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1-1 to 1-8	Original	6-1 to 6-27	Original
2-1 to 2-2	Original	i-0 to i-4	Original
2-2a, 2-2b	Change 1		

		Contract No.
Hewlett-Packard Company	Palo Alto, California	N 600(24)60858
and		
Lavoie Laboratories, Inc.	Morganville, New Jersey	N 600(24)62757

Errors found in this publication (other than obvious Typographical errors), which have not been corrected by means of Temporary Corrections or Permanent Changes should be reported. Such report should include the complete title of the publication and the publication number (short title); identify the page and line or figure and location of the error; and be forwarded to the Electronics Publications Section of the Bureau of Ships.

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UNCLASSIFIED

21 April 1965

PERMANENT CHANGE NUMBER 1
TO NAVSHIPS 95706
INSTRUCTION SHEET

1. GENERAL.

1.1 This change is in effect upon receipt and supersedes the basic publication for the pages affected.

1.2 The purpose of this change is to bring the basic publication, NAVSHIPS 95706 dated 24 March 1964, up to date with equipment production changes.

1.3 This change consists of pages 1 thru 4 and shall be inserted in the manual behind the front cover, preceding any previous changes.

1.4 With the exception of certain items specified in change 1, this instrument is similar to the AN/USM-140B, and also similar electrically, to the Oscilloscope AN/USM-141A. Subsequent references to the AN/USM-140B shall be understood to apply equally to the AN/USM-140D.

1.5 These changes apply only to Oscilloscope AN/USM-140D as manufactured by Lavoie Laboratories, Inc., Morganville, N.J. under Contract N600(24)62757.

2. INSTRUCTIONS.

2.1 Starting at the rear of the book, insert page 4-55, 4-56 in Section 4.

2.2 Working toward the front of the book, insert additional change pages. Before securing the front cover, make sure that all change pages are in place.

2.3 When the manual has been completely re-assembled, proceed with the pen-and-ink corrections as outlined below.

3. PEN-AND-INK CORRECTIONS.

3.1 The purpose of making pen-and-ink corrections is to avoid the unnecessary handling of additional pages that have minor changes or corrections. Mark each page according to the instructions given. All page, paragraph, line, figure, and table numbers specified in the instructions, unless otherwise specified, refer to those of the original or existing pages in the book and not those just inserted. After marking a page, change the word "ORIGINAL" at the bottom of the page to "CHANGE 1".

3.2 Make the pen-and-ink changes to the List of Illustrations as follows:

PAGE NO.	ACTION
v	Section 1: Add "Figure 1-1a. Oscilloscope AN/USM-140D . . . . 1-0a, 1-0b" after "Figure 1-1, Oscilloscope AN/USM-140B. . . . 1-0".
v	Section 2: Add "Figure 2-2a. Power Connections for Operating Oscilloscope AN/USM-140D on 230-volt Power Line . . . . 2-2a, 2-2b" after "Figure 2-2. AN/USM-140B Dimensions . . . . 2-2".
v	Section 4: Add "Figure 4-22a. Fan Shroud and Power Transistor Assembly, Location of Test Points and Connections for Oscilloscope AN/USM-140D . . . . 4-55, 4-56" after "Figure 4-22. Right Side View of MX-2930B/USM, Location of Test Points . . . . 4-54".

3.3 Make the pen-and-ink changes to the Parts List of Table 6 as follows: (These changes are not valid for Oscilloscope AN/USM-140B and AN/USM-141A.)

PAGE NO.	ACTION
6-2	For A1 change Mfr. No. to "35225", change Part No. to "K50430039".
	For A2 change Mfr. No. to "35225", change Part No. to "K50430042".
	For A3 change Mfr. No. to "35225", change Part No. to "K50430059".

PAGE NO.	ACTION
6-2 (Cont)	For A100 change Mfr. No. to "35225", change Part No. "K50430301".
	For A101 change Mfr. No. to "35225", change Part No. to "K50430062".
	For A103 change Mfr. No. to "35225", change Part No. to "K50430302".
	For A200 change Mfr. No. to "35225", change Part No. to "K50430097".
	For A201 change Mfr. No. to "35225", change Part No. to "K50430053".
	For A202 change Mfr. No. to "35225", change Part No. to "K50430036".
6-3	For A203 change Mfr. No. to "35225", change Part No. to "K50430055".
	For A300 change Mfr. No. to "35225", change Part No. to "K50430099".
	For A301 change Mfr. No. to "35225", change Part No. to "K50430501".
	For A302 change Mfr. No. to "35225", change Part No. to "K50430045".
	For A401 change Mfr. No. to "35225", change Part No. to "K50430051".
	For A402 change Mfr. No. to "35225", change Part No. to "K50430048".
	For A403 change Mfr. No. to "35225", change Part No. to "K50430006".
	For A603 change Mfr. No. to "35225", change Part No. to "K50430007".
	For A604 change Mfr. No. to "35225", change Part No. to "K50430007".
	For A1000 change Mfr. No. to "35225", change Part No. to "K50430096".
6-4	Add these items: For B401 change to read as follows: "B401A Fan, Propeller Type Mfr. No. 09731, Part No. OUH-731-5". "B401B Filter Assembly; Mfr. No. 35225, Part No. P33600020".
6-5	For C119 change CM15D221JN3 to "DM15D221JN3".
6-6	For C318, change CM20B561KN3 to "CM20C561JN3". For C1003 change CM35D472JN3 to "CM35C472JN3".
6-7	For FL401 change Mfr. No. to "35225" and Part No. to "P50439017". For L4 change 5 uh ± 1070 to "5 uh ± 10%"; change Mfr. No. to "35225", change Part No. to "P50439019". For L15 change Mfr. No. to "35225", change Part No. "P50439020".
6-8	For L201 change Mfr. No. to "35225", change Part No. to "P32130092". For L402 change Mfr. No. to "35225", change Part No. to "P50439022". For L403 change Mfr. No. to "35225", change Part No. to "P50439023". For L406 change Mfr. No. to "35225", change Part No. to "P50439024".
6-10	For R50, change RN70B1503F to "RN70D1503F". For R80, change RL32AD571J to "RL32AD561J".
6-11	For R109 change Mfr. No. 07511 to "07115". For R121 change RN70B4993F to "RN70D4993F".
6-12	For R160 change RL42AD203K to "RL42AD203J". For R169 change RN75B2552F to "RN75B2522F". For R205 change RN65B1004F to "RN65D1004F". For R209 change Mfr. No. to "71450", change Part No. to type "RV4, RGC 90". For R216 change Mfr. No. to "73138", change Part No. to "SC731".

PAGE NO.	ACTION
6-13	For R223A/B change Mfr. No. to "01121", change Part No. to "A-B JD1L040S101MC". For R233, change RN70B1182F to "RN70D1182F". For R235, change RN70B2121F to "RN70D2121F". For R237 change RN70B3650F to "RN70D3650F". For R238 change RN70B1210F to "RN70D1210F". Add R277, RESISTOR: Same as R1.
6-14	For R334, change to read "same as R313". For R350, change RN70B1000F to "RN70D1000F". For R351, change RN70B60R4F to "RN70D60R4F". For R352, change RN70B40R2F to "RN70D40R2F". For R353, change RN70B2003F to "RN70D2003F". For R358, change RN70B4533F to "RN70D4533F". For R359, change RN70B4023F to "RN70D4023F".
6-15	For R368, change RW59GR25 to "RW59GR26". For R403, change RW31G500 to "RW31G510". For R421, change RW32W710 to "RW32V710". For R424, change RW32V500 to "RW32V510".
6-16	For R1009, change Mfr. No. to "71450", change Part No. to "RGC-90". For R1017, change RN70B3653F to "RN70D3653F". For S1 change Mfr. No. to "76854", change Part No. to "Type 175". For S101, change Mfr. No. to "35225", change Part No. to "P50439044". For S102, change Mfr. No. to "35225", change Part No. to "P50439045". For S202, change Mfr. No. to "35225", change Part No. to "P50439046". For S302, change Mfr. No. to "35225", change Part No. to "P50439047". For S402, change Mfr. No. to "01295", change Part No. to "(20400D/L140-2/561-2)". For S1001 change Mfr. No. to "35225", change Part No. to "P50439053".
6-17	For T301, change to read "Transformer, High Voltage"; Mfr. No. "35225", Part No. "P50439054". For T401, change Mfr. No. to "35225", change Part No. to "P50439055".
6-19	For A500, change Mfr. No. to "35225", change Part No. to "K50430134". For A501 change Mfr. No. to "35225", change Part No. to "K50430117". For A502 change Mfr. No. to "35225", change Part No. to "K50430114". For A503 change Mfr. No. to "35225", change Part No. to "K50430132".
6-20	For C1589, change CC20CH8R2C to "CC20CH080D". For L501 change Mfr. No. to "35225", change Part No. to "P50439025".
6-22	For R516, change RN60B1301F to "RN60D1301F". For R518, change RN65B1502F to "RN65D1502F".
6-23	For R553, change RC07GF182K to "RC20GF182K". For R555, change S/A R109 to "S/A R88". For R561, change RC07GF152K to "RC20GF152K". For R563, change RN70B1823F to "RN70D1823F". For R575, change RW55GR471 to "RW55F471F".
6-24	For R591 change RC20GF182K to "RC20GF122K". For R1501 change RN6B6043 to "RC65D6043F". For R1502 change RN65B6653F to "RN65D6653F". For R1504 change RN65B2493F to "RN65D2493F". For R1507 change RN65B9533F to "RN65D9533F". For R1508 change RN65B4122F to "RN65D4122F". For R1509 change RN65B9763F to "RN65D9763F".

PAGE NO.	ACTION
6-24 (Cont)	For R1513 change RN65B1022F to "RN65D1022F". For R1516 change RN65B4021F to "RN65D4021F". For R1519 change RN65B2001F to "RN65D2001F". For R1523 change RN65B1001F to "RN65D1001F".
6-25	For S502, change Mfr. No. to "35225", change Part No. to "P50439050". For S505, change Mfr. No. to "35225", change Part No. to "P50439051". For S506, change Mfr. No. to "35225", change Part No. to "P50439052". For T501, add Description, Mfr. No. 35225, Part No. P50439056.

3.4 Make the pen-and-ink change to the Index as follows:

PAGE NO.	ACTION
i-2	Index (O): Add "Outline drawing, AN/USM-140D . . . . (2-2a)" after "Outline drawing . . . . (2-1)".

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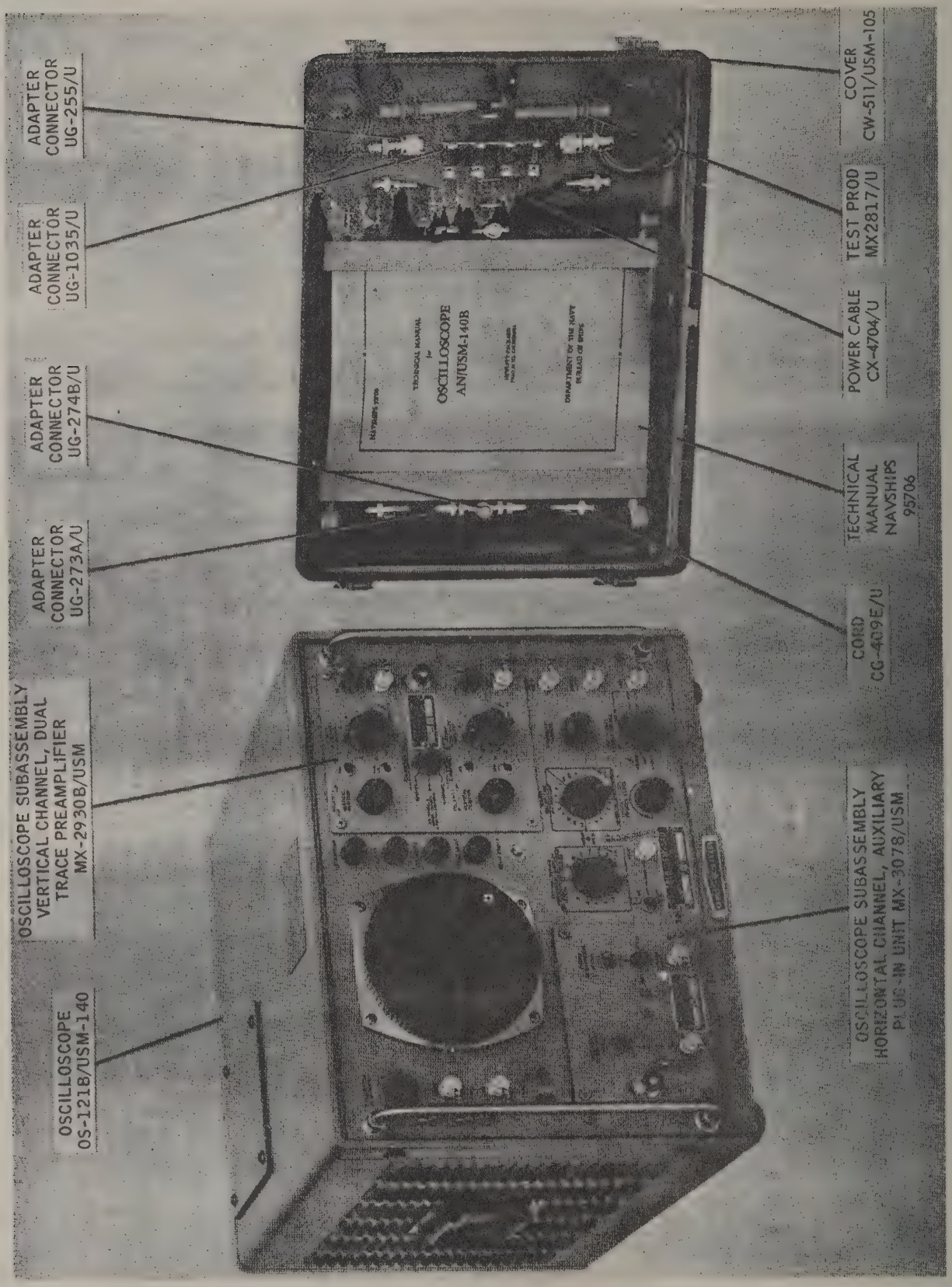


Figure 1-1. Oscilloscope AN/USM-140B

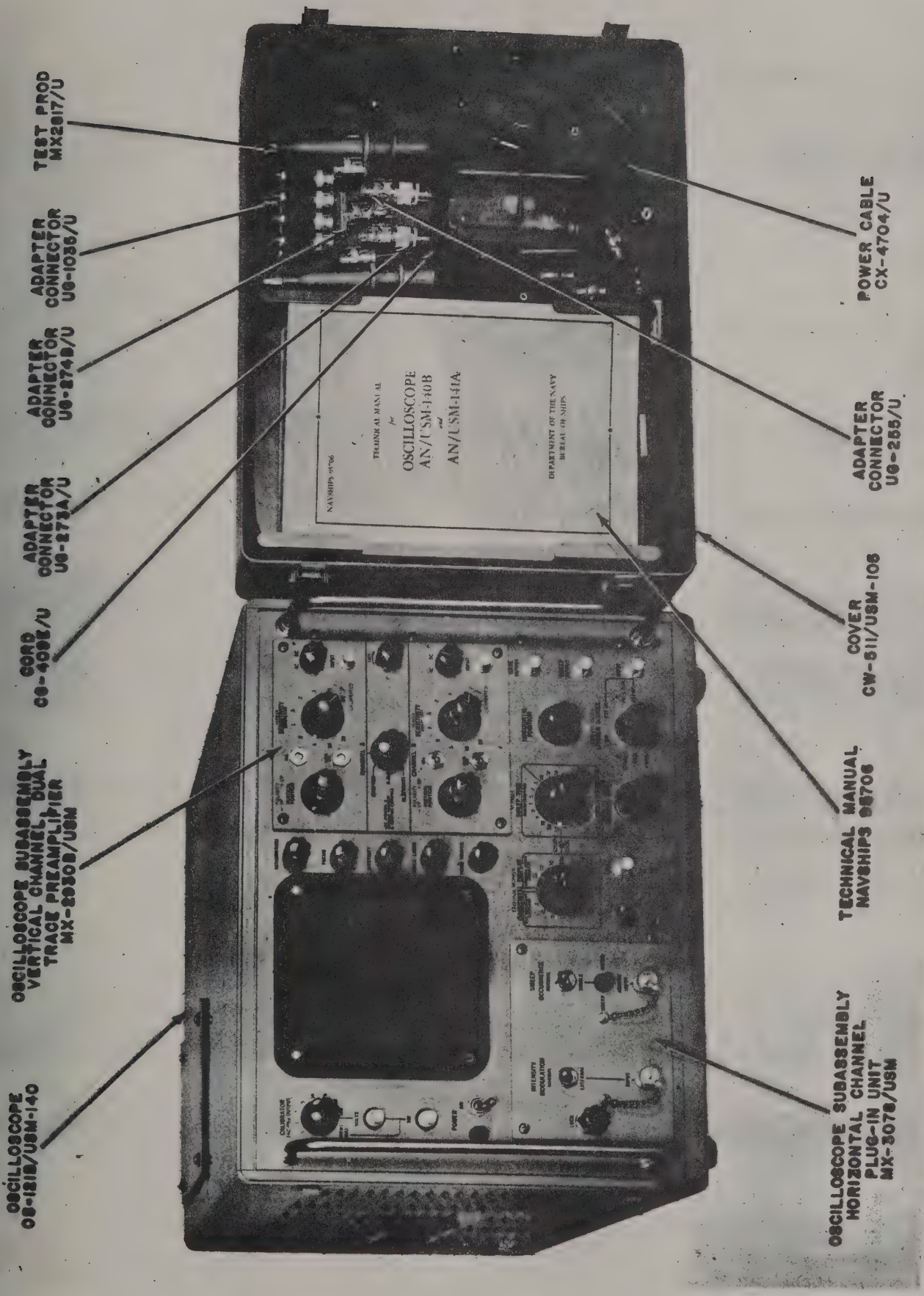


Figure 1-1a. Oscilloscope AN/USM-140D

SECTION 1

GENERAL DESCRIPTION

1-1. SCOPE.

NAVSHIPS 95706 is a single-volume technical manual that includes operating and servicing instructions and a list of replaceable parts prepared in accordance with MIL-M-15071E(SHIPS) for Oscilloscopes AN/USM-140B and AN/USM-141A. The electrical specifications, operating and servicing instructions, schematic diagrams and parts list are identical for both models. The AN/USM-140B is the portable model for bench-top use; the AN/USM-141A is designed for permanent installation in a standard 19-inch wide rack. No other publications are required or supplied for these oscilloscopes at the date of this publication. Subsequent references to the Oscilloscopes in this manual will list only the cabinet model AN/USM-140B.

1-2. GENERAL DESCRIPTION.

The AN/USM-140B is a precision high-speed oscilloscope for displaying the waveforms of electrical voltages at frequencies ranging from direct current to 22 megacycles (equivalent to a risetime of 16 nanoseconds). Vertical deflection sensitivity is continuously adjustable from 200 volts to 20 millivolts per centimeter; horizontal deflection sensitivity is continuously adjustable from 100 volts to 0.1 volt per centimeter at frequencies from direct current to 1 megacycle per second. Sweep rates are continuously adjustable from 15 seconds to 0.1 microsecond per centimeter. The sweep can be synchronized with an external signal or with the signal being viewed. Polarity and sensitivity of the synchronization are selectable to permit synchronization from different voltage points on complex waveforms.

The AN/USM-140B is especially developed for general-purpose use in US Navy ship and shore electronic maintenance and research facilities. It is designed for versatility, and reliability under a wide range of environmental conditions, combined with wide frequency range, accurate calibration, and stable synchronization at high sweep rates. Sweep rate, sweep expansion and sensitivity controls are direct-reading. Each calibrated step-type control is equipped with a potentiometer to give continuous adjustment between steps. Special features include: a beam-finder pushbutton to simplify the problem of finding and centering off-screen traces; a front-panel calibrator that provides squarewave voltages from 0.2 millivolt to 100 volts for checking the accuracy of the vertical and horizontal sensitivity selectors; an internal 200-nanosecond vertical signal delay to permit viewing the leading edge of the signal that triggers the sweep; sweep and gating output signals for use in external equipment.

Typical uses for the oscilloscope include precise waveform analysis and oscillography used in the research, design and service of electronic circuits, waveform observations required for adjusting operating equipment such as radio transmitters, and precise measurements of time and frequency.

1-3. DESCRIPTION OF UNITS.

The AN/USM-140B consists of a major oscilloscope unit, two plug-in units which install in recesses in the front panel of the major unit, and a group of accessory cables and connectors stored in the detachable front cover.

a. OSCILLOSCOPE OS-121B/USM-140.— The major unit, Oscilloscope OS-121B/USM-140, contains the power supplies, horizontal amplifier, sweep generator, main vertical amplifier, cathode ray tube, calibrator and the controls associated with these circuits.

b. OSCILLOSCOPE SUBASSEMBLY, VERTICAL CHANNEL, DUAL TRACE PREAMPLIFIER.— This plug-in unit, MX-2930B/USM, permits simultaneous observation of two separate vertical input signals, each signal being controlled and positioned independently. This unit provides three methods of observing the two input signals, 1) each input signal on alternate sweeps, 2) each input signal on alternate 1-microsecond segments of the two input waveforms, 3) the difference voltage of the two input signals combined. Either channel can be also selected for single-channel operation.

c. OSCILLOSCOPE SUBASSEMBLY, HORIZONTAL CHANNEL, AUXILIARY PLUG-IN UNIT.— This plug-in unit, MX-3078/USM, is required for normal repetitive sweeps and provides for single-sweep operation with either manual or external arming of the sweep, and also permits intensity modulation of the trace by external signals.

1-4. REFERENCE DATA.

The AN/USM-140B is designed for continuous usage in ambient temperatures from -28° C to +50° C with relative humidity up to 99%. Within this range, the equipment will operate with the performance and accuracy specified below.

a. EACH VERTICAL CHANNEL. —

(1) Sensitivity Range (both AC and DC coupling): Ten calibrated ranges in 1-2-5-10 sequence from 0.02 volt/cm to 20 volts/cm; accuracy ±5%. Vernier control extends sensitivity to 50 volts/cm.

(2) Frequency Pass Band:

DC coupled: dc to 22 mc (down 3 db points at 22 mc), 0.016 μsec rise time;

AC coupled: 2 cps to 22 mc between 3 db points (0.016 μsec rise time).

(3) Input Impedance: 1 megohm ±10% shunted by 30 pf on all ranges. 10 megohms shunted by 10 pf when using Test Prod MX-2817/U.

(4) Display Polarity: Selectable, + up or - up.

(5) Electronic Switching: Dual channel display by alternate sweep, or chopped at approximately 1 mc with trace blanking during switching.

b. DIFFERENTIAL INPUT.—

(1) Both input attenuators may be switched to one channel to give differential input. The input attenuators may be set separately to equalize input signals of different levels.

(2) Common Mode Rejection: At least 40 db at maximum sensitivity; at least 30 db when using attenuators.

c. SWEEP AND SYNCHRONIZATION.—

(1) Internal Sweep: 24 calibrated ranges in 1-2-5-10 sequence from 0.1 μsec/sec to 5 sec/cm, accuracy ±3%. Vernier control extends slowest sweep to 15 sec/cm.

(2) Sweep Expansion: 7 calibrated ranges, in 1-2-5-10 sequence up to X100. Increases fastest sweep speed to 0.02 μsec/cm. Accuracy: X1, X2, and X5 ranges ±3%; X10 and X20: ±5%; X50 and X100: ±10% to 0.02 μsec/cm.

(3) Trigger Modes:

From external signals 0.5 volt peak-to-peak or greater;

from internal signals having 0.5 cm vertical deflection or greater;

from internal source of line frequency.

(4) Trigger Level and Slope: Uses positive or negative-going voltage, with trigger point continuously adjustable from -30 to +30 volts on external signals or any visible point on the waveform of internal signals.

(5) External Trigger Input Impedance: 1 megohm ±10% shunted by 70 pf.

(6) Sweep Output: -50 to +50 volts (approx).

(7) Gate Output: +50 volts (approx); length equal to duration of sweep.

d. HORIZONTAL AMPLIFIER.—

(1) Bandwidth:

DC coupled: dc to 1 mc (down 3 db at 1 mc);

AC coupled: 2 cps to 1 mc between 3 db points.

(2) Sensitivity: 7 calibrated ranges, in 1-2-5-10 sequence from 0.1 volt/cm to 10 volts/cm. Vernier control extends sensitivity to 25 volts/cm.

(3) Input Impedance: 1 megohm ±10% shunted by 30 pf.

e. CALIBRATOR.—

(1) Voltage: 9 calibrated ranges in 1-2-5-10 sequence, from 0.2 millivolts to 100 volts peak-to-peak; accurate to within ±3%.

(2) Waveform: 1000-cycle square wave, 1-μsec rise and decay time.

(3) Current: 5 milliamperes peak-to-peak, ±3%.

(4) Loading: 1 megohm or greater.

f. CATHODE RAY TUBE.— P2 phosphor with compatible green filter. (P31 phosphor may also be used).

(1) Graticule: 10 cm long by 4 cm high graduated in centimeter squares with 2 mm subdivisions on horizontal and vertical axes. Adjustable, edge lighting.

(2) Deflection Plate Connection: Pin type terminals.

(3) Deflection Sensitivity:

Vertical: approximately 20 volts/cm.

Horizontal: approximately 35 volts/cm.

(4) Intensity Modulation: + 20 volt pulse blanks CRT trace of normal intensity.

g. POWER REQUIREMENTS: 115 vac, ±10%; 50~±10%, 60~±10%, and 400~±10%; single phase, approximately 480 watts.

h. DIMENSIONS: See figures 2-2 and 2-3.

1-5. EQUIPMENT SUPPLIED.

The equipment supplied under AN/USM-140B is listed in table 1-1. In addition to the basic oscilloscope and its two plug-in units, two test prods, two coaxial cables and an assortment of connector adapters are provided to facilitate connecting the oscilloscope to a variety of equipments and circuits. Test Prods MX-2817/U (MX-4037/U may also be used) are specially designed broad-band probes equipped with alligator jaws for easy attachment to most forms of electrical conductors. Each test prod contains a compensated voltage divider that gives a 10-times increase in the input resistance of the oscilloscope channel with which it is used (vertical or horizontal input), with a reduced input capacity of 10 picofarads; use of the prod attenuates the input signal and reduces the height of the displayed waveform by a factor of 10.

Two BNC "TEE" adaptors are provided to facilitate connecting the same input signal to two different input connectors. Four BNC-to-Binding Post adapters are supplied to permit connecting plain wire leads to the type BNC connectors on the oscilloscope. Two UHF-to-BNC adapters are supplied to permit connection to equipments using UHF connectors. Two eight-foot coaxial cables terminated in BNC connectors are provided for connection to external equipments.

1-6. EQUIPMENT AND PUBLICATIONS REQUIRED BUT NOT SUPPLIED.

A list of all equipments and publications required but not supplied is provided in table 1-2.

TABLE 1-1. EQUIPMENT SUPPLIED WITH OSCILLOSCOPE AN/USM-140B AND AN/USM-141A

QTY PER EQUIP	NOMENCLATURE		UNIT NO.	OVERALL DIMENSIONS (IN.)			VOLUME (CU. IN.)	WEIGHT (LB)
	NAME	DESIGNATION		HEIGHT	WIDTH	DEPTH		
1	*Oscilloscope Assembly	AN/USM-140B		14-3/4	19-3/4	24	6700	103.5††
1	*Oscilloscope	OS-121B/USM-140	1	12-1/4	18	22-7/8	5100	84.5
1	Dual Trace Preamplifier	MX-2930B/USM	2	7	6	11-1/4	470	7
1	Auxiliary Plug-In	MX-3078/USM	3	4-5/8	6	10-7/8	285	2
2	Prod, test	MX-2817/U or MX-4037/U	4					
2	Connector, adapter	UG-255/U						
2	Connector, adapter	UG-273A/U						
4	Connector, adapter	UG-1035/U or UG-1441/U						
1	Cable Assembly, Power, Electrical	CX-4704/U (8 ft. 0 inch)						
2	Cord	CG-409E/U (8 ft. 0 inch)						
2	Connector, adapter	UG-274B/U						
2	Technical Manual	NAVSHIPS 95706						3.4
1	*Cover	CW-511/USM-105		14	19-1/2	3		4.5
1	**Oscilloscope Assembly	AN/USM-141A		12-7/32	19	24-3/16		92.5††
1	**Oscilloscope	OS-122A/USM-141	1†	12-7/32	19	24-3/16		78

*Not included in AN/USM-141A.
**Not included in AN/USM-140B
†Internal parts of AN/USM-141A are identical to AN/USM-140B.
††Shipping weight: 136 lbs

TABLE 1-2. EQUIPMENT AND PUBLICATIONS REQUIRED BUT NOT SUPPLIED

QTY PER EQUIP	NOMENCLATURE		REQUIRED USE	REQUIRED CHARACTERISTICS
	NAME	* DESIGNATION		
1	DC Voltmeter	CCUH-825-A-G (AN/USM-98 or Fluke Model 801 or 803)	Precision measurement of low voltage power supply and other dc voltages	Voltage Range: 0 to 400 volts Input Impedance: 1 megohm minimum Accuracy: 0.05%
1	High Voltage DC Voltmeter	AN/USM-116 (Hewlett-Packard Model 410B)	Voltage and resistance measurements, high-voltage measurements	Voltage Range: to 5000 volts Input Impedance: 500 megohms min. Accuracy: 8%
1	Constant Amplitude Generator	No preferred type Tektronix 190A	Passband measurement	Frequency Range: 50 kc to 30 mc Output: 1 volt Accuracy: 2%
1	Voltmeter Calibrator	No preferred type Hewlett-Packard Model 738A	Calibrated signal source, dc and 400 cps ac	Voltage Range: 1 to 100 volts p-p Accuracy: 1%
1	Square Wave Generator	No preferred type Tektronix 107	High frequency compensation setting	Rise Time: 3 nsec max. Output: 0.5 volt min.
1	Square Wave Generator	TS-583-B (TS-583/U or Hewlett-Packard Model 211A)	Attenuator compensation setting over a wide frequency range	Rise Time: 0.1 μsec max. Output: up to 25 volts Frequency Range: 1 to 100 kc
1	Time-Mark Generator	AN/USM-108 (Tektronix Model 180A)	Sweep time calibration	Range: 100 msec to 0.1 μsec
1	Oscilloscope	AN/USM-140( ) (Hewlett-Packard Model E03-170B)	Waveform comparison	Calibration: Vertical & horizontal Input Impedance: 10 megohm/10 pf
1	High-Gain Differential Amplifier (Oscilloscope Plug-In)	AM-3567/USM	Measuring low-level ac and ripple waveforms	Sensitivity: 1 mv/cm from dc to 300 kc Sensitivity: 50 mv/cm from dc to above 2.0 mc

* First entry, preferred test instrument; second entry, commercial or military alternate.

TABLE 1-2. (Continued)

QTY PER EQUIP	NOMENCLATURE		REQUIRED USE	REQUIRED CHARACTERISTICS
	NAME	* DESIGNATION		
1	Tube Tester	AN/USM-118( )	Testing tubes for dynamic and static characteristics	—
1	Q Meter	AN/URM-90	Capacitance measurement	Calibration: ±0.3 pf to 50 pf
1	Electronic AC Voltmeter	ME-6E/U (ME-6/U or Hewlett-Packard Model 400 series)	AC voltage measurements	Range: 1 mv full scale to 300 volts full scale
1	Transistor Tester	TS-1100( )/U	Testing transistors	—
1	Main Vertical Amplifier Test Connector	Construct as shown in figure 5-1	To facilitate direct signal connection to main vertical amplifier	—
1	Special Vertical Extender	Construct as shown in figure 4-12	To facilitate operation of vertical plug-in unit outside of oscilloscope	—
1	52-Ohm Feed-Through Termination for Tektronix Instruments	Tektronix 011-001	Proper-Impedance Termination for Tektronix Instruments	—
1	Instruction Book for DC Voltmeter	Fluke commercial manual for Model 801, 803 or 825A		
1	Instruction Book for High Voltage DC Voltmeter AN/USM-116	NAVSHIPS 93808		
1	Instruction Book for Constant Amplitude Generator, Tektronix Model 190A	Tektronix commercial manual for Model 190A		
1	Instruction Book for Voltmeter Calibrator, Hewlett-Packard Model 738A	T.O. 33A1-12-265-1 (Hewlett-Packard commercial manual for Model 738A)		
1	Instruction Book for Square Wave Generator, Tektronix Model 107	T.O. 33A1-8-157-1 (Tektronix commercial Manual for Model 107)		
1	Instruction Book for Square Wave Generator TS-583-B or TS-583/U	TM 11-5024 (Hewlett-Packard commercial Manual for Model 211A)		

* First entry, preferred test instrument; second entry, commercial or military alternate.

TABLE 1-2. (Continued)

QTY PER EQUIP	NOMENCLATURE		REQUIRED USE	REQUIRED CHARACTERISTICS
	NAME	DESIGNATION		
1	Instruction Book for Time Mark Generator AN/USM-108	Tektronix commercial manual for Model 180A		
1	Instruction Book for High-Gain Differential Amplifier (Oscilloscope Plug-In) AM-3567/USM	NAVSHIPS 95680		
1	Instruction Book for Q Meter AN/URM-90	TM 11-2646A		
1	Instruction Book for Tube Tester AN/USM-118( )	NAVSHIPS 93883		
1	Instruction Book for Electronic AC Voltmeter ME-6E/U	NAVSHIPS 95564		
1	Instruction Book for Transistor Tester TS-1100( )/U	NAVSHIPS 95693		

1-7. AUXILIARY ACCESSORY EQUIPMENT.

A list of three accessory plug-in units which may be used with the AN/USM-140B is provided in table 1-3. These units are not supplied with the AN/USM-140B, but may be procured separately to increase the oscilloscope's versatility. One unit, Time Delay Generator MX-2962/USM, can be used in place of the MX-3078/USM to provide an accurately calibrated, adjustable time delay between the time of an externally generated sweep trigger and the start of the oscilloscope sweep. Refer to NAVSHIPS 94309 for instructions. The second is High-Gain Differential Amplifier, AM-3567/USM, which can be used in place of the MX-2930B/USM to permit display of the differential signals between two channels. The third is High-Gain Wide-Band Amplifier, AM-3568/USM, which can be used in place of the MX-2930B/USM to view low-level wide-band signals requiring high-gain.

TABLE 1-3. ACCESSORIES FOR OSCILLOSCOPE AN/USM-140B

MODEL	NAME	FUNCTION
AM-3567/USM	High-Gain Differential Amplifier	Used in place of Dual-Trace Preamplifier MX-2930B/USM for greater input sensitivity. Provides 1-millivolt sensitivity from dc to 300 kc 50-millivolt sensitivity from dc to 12 mc
AM-3568/USM	High-Gain Wide-Band Amplifier	Used in place of Dual-Trace Preamplifier MX-2930B/USM for viewing fast-rise signals. Provides single-channel, 30-mc passband with 0.05-volt/cm to 50-volt/cm sensitivity.
MX-2962/USM	Time Delay Generator	Used in place of Horizontal Channel Auxiliary Plug-in Unit MX-3078/USM to allow expansion of a portion of the waveform. Provides accurately calibrated, adjustable sweep delay from 10 sec to 1 usec.

1-8. EQUIPMENT SIMILARITIES.

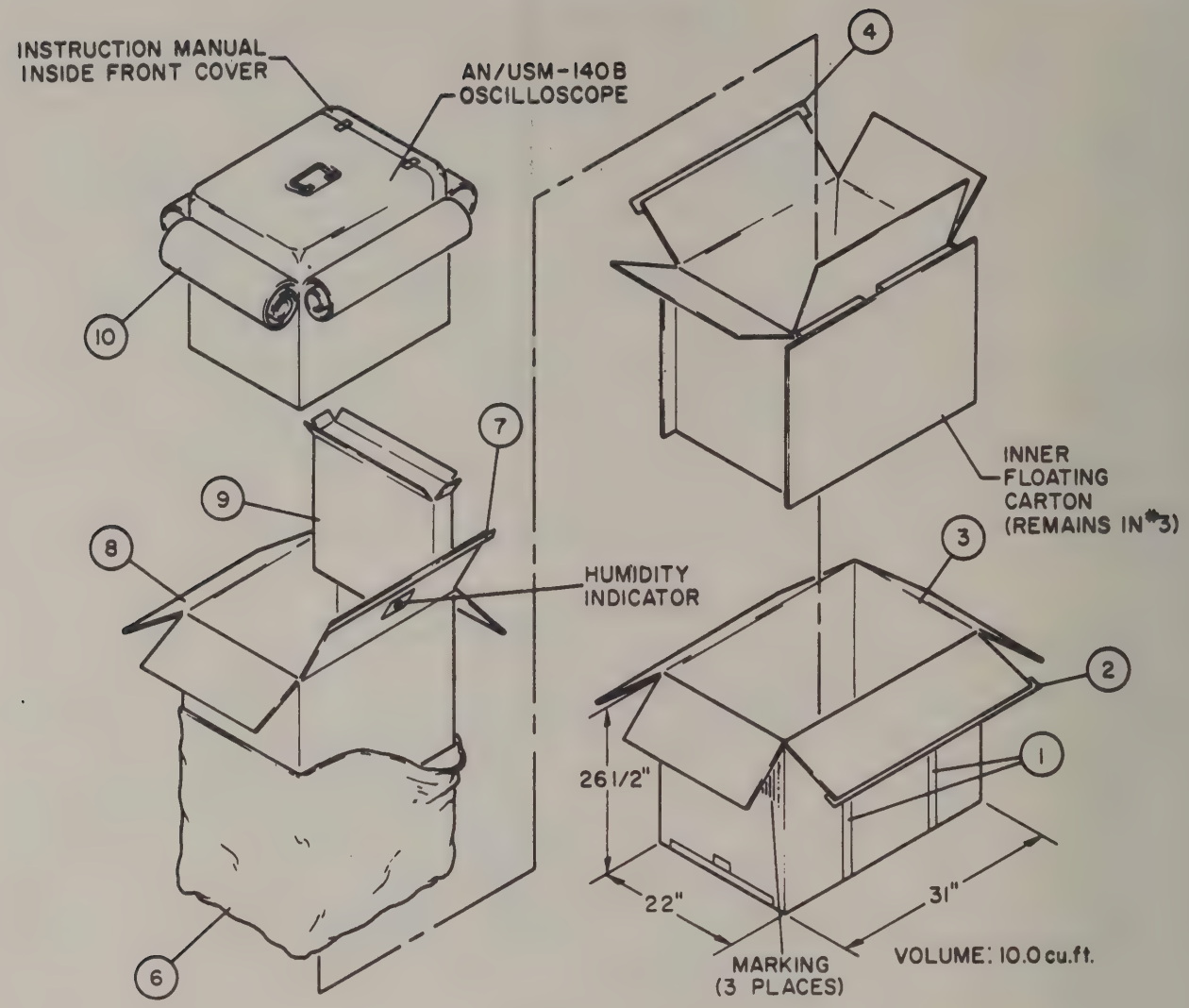
This manual covers both the AN/USM-140B and AN/USM-141 oscilloscopes. The AN/USM-141 is a rack-mount version of the AN/USM-140B, and the the two are electrically identical, as described in paragraph 1-1.

1-9. FACTORY OR FIELD CHANGES.

Oscilloscope AN/USM-140B (and Oscilloscope AN/USM-141) are new instruments; no factory or field changes have been made as of date of issue.

1-10. PREPARATION FOR RESHIPMENT.

Electronic equipment must be packed with special care. The package in which the equipment is originally shipped is designed to give the instrument full protection from adverse environments and from the shock and vibration incurred in shipment. It should be preserved and utilized for reshipment wherever possible. When preparing the AN/USM-140B for shipment, stow the accessory probes, cables, and connectors in their holders inside the cover of the instrument, and lock the cover in place. If the factory-designed package is not in satisfactory condition, pack in accordance with MIL-P-116 and MIL-E-17555E.



UNPACKING INSTRUCTIONS

OPEN PACKAGE IN ORDER OF LISTING

ITEM	ACTION	MATERIAL
1	CUT	STEEL STRAPPING
2	REMOVE	TAPE – 3", GUMMED, FILAMENT
3	OPEN	CORRUGATED CARTON
4	REMOVE	TAPE – 3", GUMMED, FILAMENT
5	OPEN	INNER FLOATING CARTON
6	OPEN	BARRIER BAG (MOISTURE PROOF)
7	REMOVE	TAPE – 3", GUMMED, FILAMENT
8	OPEN	CORRUGATED CARTON
9	REMOVE	CORRUGATED DESICCANT COVER
10	OPEN	WRAPPER (PAPER)

Figure 2-0. Exploded View of Shipping Package for AN/USM-140B Oscilloscope

SECTION 2

INSTALLATION

2-1. UNPACKING AND HANDLING.

The oscilloscope is shipped with all electron tubes installed, including the cathode ray tube. Handle the instrument carefully when removing it from the shipping container.

Inspect the oscilloscope upon receipt for any damage which may have occurred in transit. Check for loose or broken knobs, bent or broken connectors, and dents or scratches on the cabinet and panel surface.

2-2. POWER REQUIREMENTS.

The oscilloscope is normally shipped from the factory for use on a single phase, 115-volt ac source. A power source of 230-volts ac may be used if proper connections are made within the oscilloscope, in accordance with the instructions given below. The frequency must be in the range of 50 to 440 cps. The power demand varies, dependent on the combination of plug-in units used. Maximum power demand does not exceed 600 watts. Make sure the power source is proper before plugging in the cord.

The power transformer has two 115-volt primary windings which are parallel-connected for 115-volt ac operation. To convert to series connection for 230-volt use, proceed as follows:

a. First remove the instrument cabinet as follows (not required for the rack-mounted AN/USM-141):

(1) Carefully place the oscilloscope with its front panel down, resting it on its carrying handles.

(2) Remove the four cabinet-retaining screws from the rear of the instrument, and lift off the cabinet.

b. Locate the power transformer T401 (see figure 5-10. Then change its primary wiring from parallel to series connection as follows, in accordance with the detail illustration in figure 2-1.

(1) Remove the jumpers between A1-A4 and A2-A5.

(2) Connect a jumper between A4-A5.

c. Locate the rectifier circuit board A401 which is also located on the chassis bottom as shown in figure 5-10. On the rectifier circuit board A401, remove jumper A. Replace it with a 100-K, 1/2-watt, 10% resistor. Remove jumper B and replace it with a 68-K, 1/2-watt, 10% resistor.

d. Replace fuses F401 and F402 with 4-ampere, slow-blow type fuses. They are located behind the plug-in vertical preamplifier, accessible from the side of the instrument as shown in figure 5-11.

e. Replace the spare fuses with 4-ampere, slow-blow type. They are located at the side of the plug-in vertical preamplifier.

f. Replace the AN/USM-140B cabinet by the reverse of step a above.

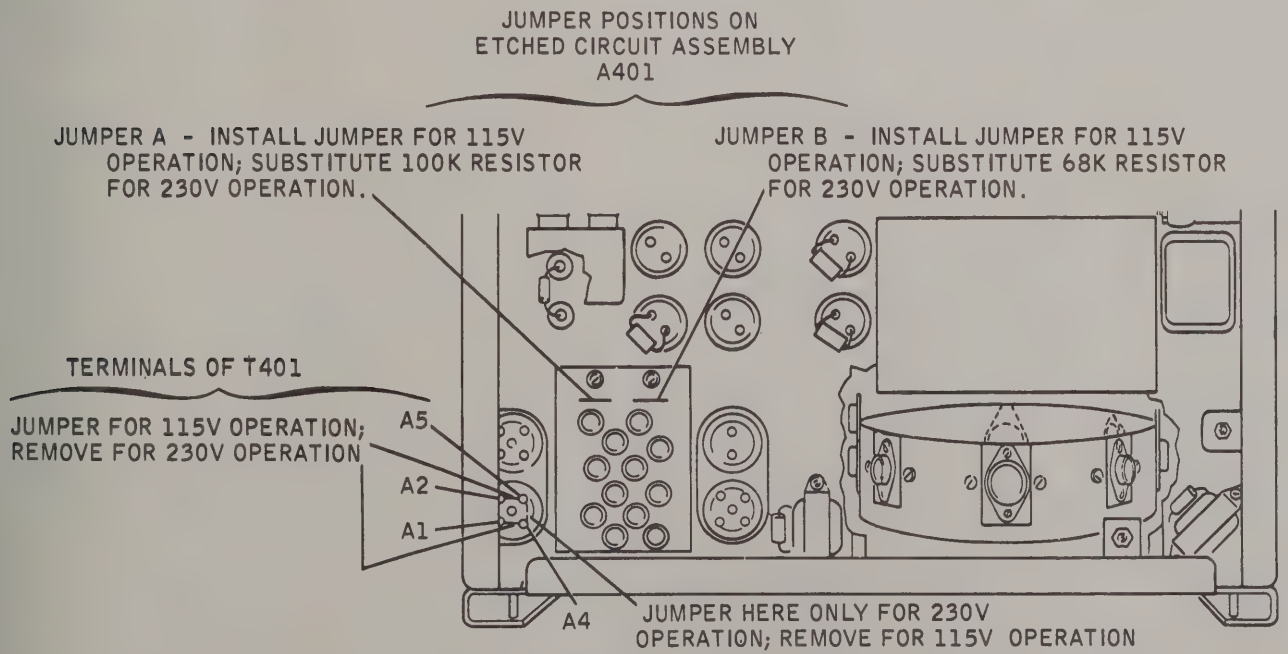

JUMPER POSITIONS ON
ETCHED CIRCUIT ASSEMBLY
A401
JUMPER A - INSTALL JUMPER FOR 115V OPERATION; SUBSTITUTE 100K RESISTOR FOR 230V OPERATION.
JUMPER B - INSTALL JUMPER FOR 115V OPERATION; SUBSTITUTE 68K RESISTOR FOR 230V OPERATION.
TERMINALS OF T401
JUMPER FOR 115V OPERATION; REMOVE FOR 230V OPERATION
A5
A2
A1
A4
JUMPER HERE ONLY FOR 230V OPERATION; REMOVE FOR 115V OPERATION

Figure 2-1. Power Connections for Operating the Oscilloscope on 230-volt Power Line

2-3. CABINET MODEL AN/USM-140B INSTALLATION.

The dimensions of the cabinet model oscilloscope are shown in figure 2-2. It may be mounted on a mobile test cart or placed on a bench, as desired. Position the oscilloscope to avoid room light reflections and to place all controls within convenient reach. Always provide adequate air circulation around the oscilloscope to ensure cooling. Do not crowd it into a tight enclosure which restricts air flow at sides and rear.

2-4. RACK MODEL AN/USM-141 INSTALLATION.

This oscilloscope model is provided in a rack mounting style to fit a standard 19-inch relay rack. This model is designated AN/USM-141. Figure 2-3 shows the dimensions of this instrument and indicates the installation details. The ends of the chassis slides attach at the front and rear of the rack as shown in figure 2-3. These slides allow the chassis to be moved in and out without tilting. Panel mounting holes match standard relay panel design. The instrument is shipped with the chassis-mounted portion of each slide attached, and the rack-mounting slides and attaching hardware (as listed in figure 2-3) packed separately ready for installation. To install, mount the rails securely as shown in figure 2-3, and slide the instrument in. Make sure adequate cooling air is available within the rack. Enclosed racks should have air ducts and filters built in.

When the slide-mounted oscilloscope is pulled out from the rack, the slide mechanism has a stop that halts it at the halfway-out position. Depressing the exposed slide button permits extension of the instrument to the full-out position. The slide safety button must be released to allow the oscilloscope to be taken out of the rack from the full-out position.

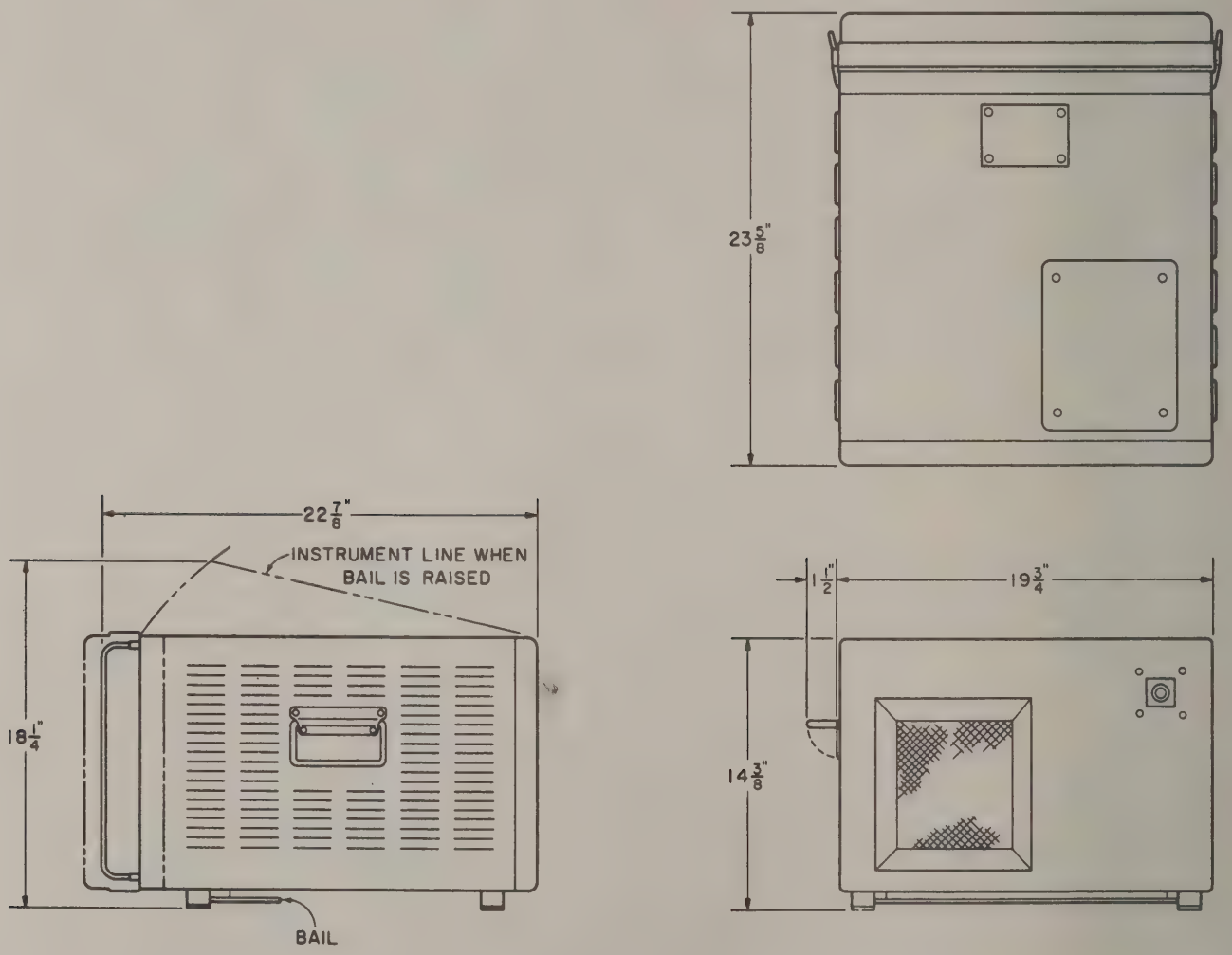


Figure 2-2. AN/USM-140B Dimensions

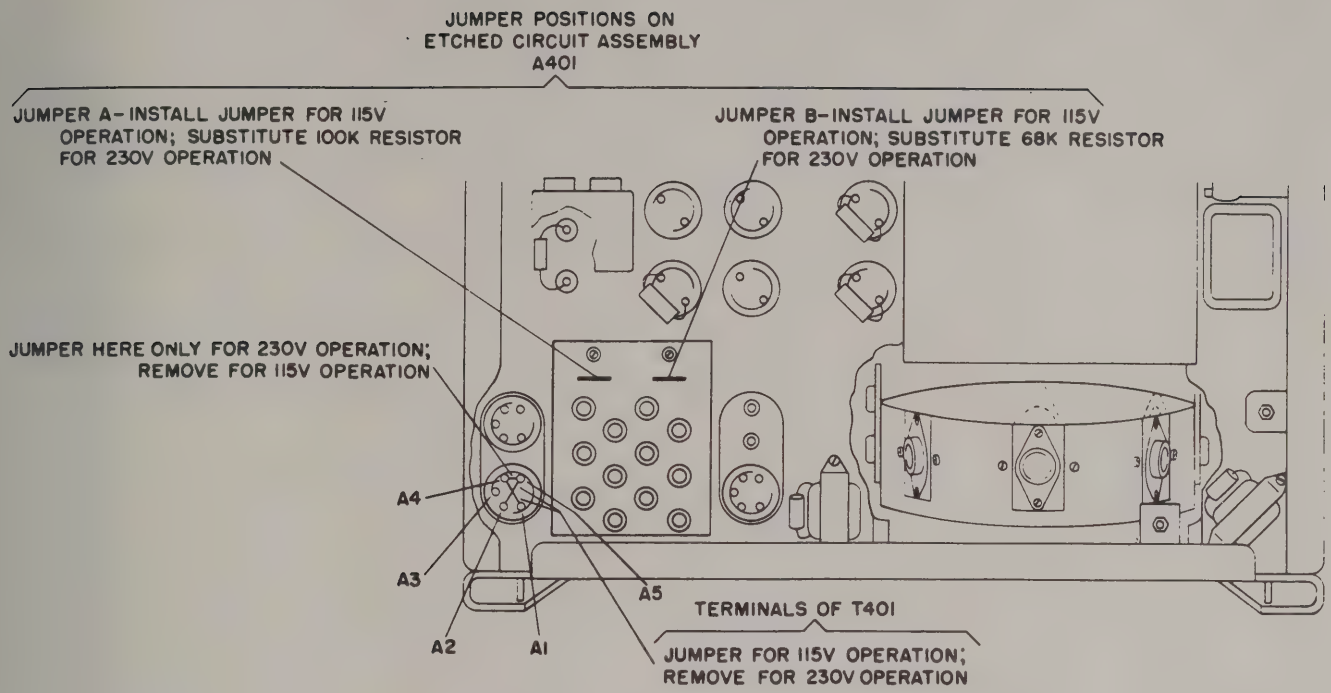


Figure 2-2a. Power Connections for Operating Oscilloscope AN/USM-140D on 230-volt Power Line

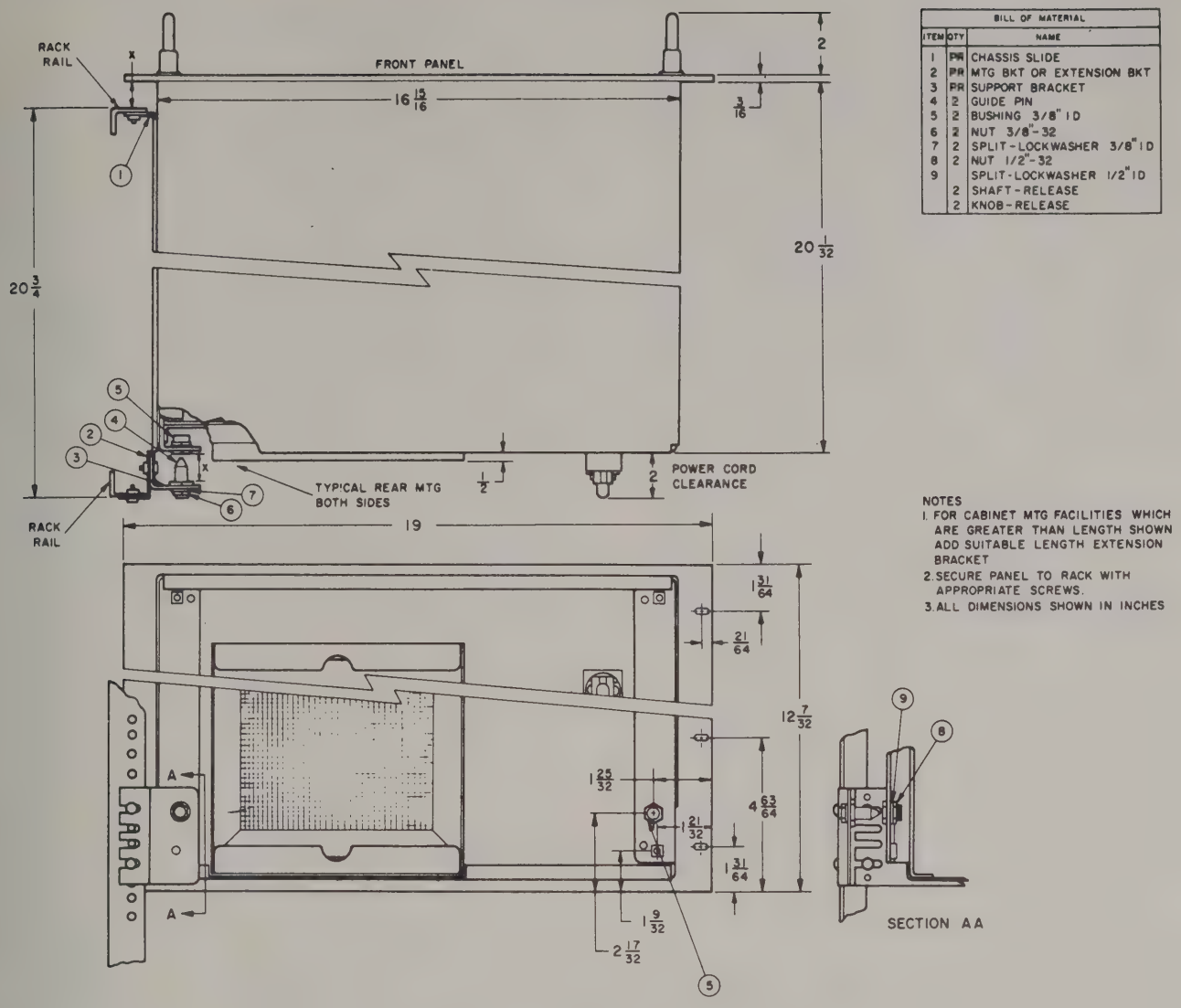

BILL OF MATERIAL
ITEM QTY NAME
1 PR CHASSIS SLIDE
2 PR MTG BKT OR EXTENSION BKT
3 PR SUPPORT BRACKET
4 2 GUIDE PIN
5 2 BUSHING 3/8" I D
6 2 NUT 3/8"-32
7 2 SPLIT-LOCKWASHER 3/8" I D
8 2 NUT 1/2"-32
9 SPLIT-LOCKWASHER 1/2" I D
2 SHAFT-RELEASE
2 KNOB-RELEASE
RACK RAIL
FRONT PANEL
TYPICAL REAR MTG BOTH SIDES
POWER CORD CLEARANCE
SECTION AA
NOTES
1. FOR CABINET MTG FACILITIES WHICH ARE GREATER THAN LENGTH SHOWN ADD SUITABLE LENGTH EXTENSION BRACKET
2. SECURE PANEL TO RACK WITH APPROPRIATE SCREWS.
3. ALL DIMENSIONS SHOWN IN INCHES

Figure 2-3. AN/USM-141 Dimensions

2-5. CABLES AND CONNECTORS.

The front cover of the oscilloscope cabinet provides the storage space for all cables and connectors that are needed to operate the oscilloscope. A list of the cables and connectors supplied is given in Table 1-1.

a. POWER CABLE.—An eight foot, three conductor power cable, CX-4704/U (8'0"), is supplied with the instrument. One end of the cable terminates in a plug which mates with a male jack on the rear of the instrument. The other end of the power cable terminates in a polarized three-contact male plug. One contact of the plug is an offset round pin which grounds the instrument chassis when the plug is used with a grounded receptacle.

To operate the instrument from a two-contact receptacle:

(1) Rotate the offset pin to the side.

(2) Loosen the screw on the offset pin and remove the green (ground) lead.

(3) Connect the green lead to ground.

(4) Insert the plug directly into the receptacle.

WARNING

If the green lead on the plug is not attached to ground when a two-contact receptacle is used, the instrument panel and cabinet may assume an off-ground potential and present a hazard to operating personnel.

b. TEST PRODS.—Two prods are supplied for connecting the two vertical input channels of the MX-2930B/USM to two external signal sources. The test prods permit quick connection to almost any form of

uninsulated circuitry. They are equipped with alligator jaws that are opened by pressing the rear flange on the prode forward. Each probe reduces the waveform height to 1/10th before application to the oscilloscope input; this sacrifice in signal level is made to increase the shunt capacitive reactance and resistance presented to the signal source. The resultant input impedance permits the probe to be connected to most circuits without excessive loading of the circuit under test.

The prods have attached cables terminated in BNC connectors for connection to the vertical channel inputs. A simple external adjustment is provided for adjusting the frequency response of the prods without the need for any additional equipment. The frequency response and waveform height division ratio should be checked whenever exact response must be assured. Refer to figure 3-2.

c. Two BNC terminated cables are supplied for connecting any of the oscilloscope inputs directly to a BNC-terminated signal source.

d. Two UHF-to-BNC adapters are provided so that connections can easily be made to equipments having UHF connectors.

e. Two BNC-to-dual banana adapters are provided to make easy connection at the oscilloscope panel to ordinary test leads terminated in banana connectors.

2-6. THE CRT BEZEL, GRATICULE AND FILTER.

The bezel for the CRT will receive standard oscilloscope cameras which are designed to be fitted over and clamped to the bezel. When using a camera on the oscilloscope, the filter and graticule may be left in position or either one may be removed if desired. The sharpest trace is obtained when using a medium intensity trace.

The graticule is etched on clear plastic. Both the graticule and filter are placed on the inside of the bezel next to the CRT face. The etched side of the graticule must be against the CRT face for least parallax. The filter is for use over the graticule to increase contrast between the trace and CRT face particularly when ambient light is bright and there are reflections on the CRT face. To remove or replace either the graticule or filter, remove the bezel by removing its four attaching screws.

2-7. INITIAL ELECTRICAL INSPECTION.

To energize the oscilloscope for the first time, and to check the oscilloscope for proper operation, follow the procedure given in figure 3-2. This procedure includes proper initial control adjustments to prepare the oscilloscope for use.

SECTION 3

OPERATION

3-1. FUNCTIONAL OPERATION.

Oscilloscope AN/USM-140B is a high-speed, precision instrument used to visually display electrical impulses and simple or complex recurrent waveforms. It consists primarily of a vertical amplifier and a horizontal amplifier which are connected to the deflection plates of a CRT. The vertical amplifier obtains signals from the vertical plug-in unit, amplifies them to the required voltage level, and applies the voltage to the vertical deflection plates of the CRT. The horizontal amplifier accepts either internally generated signals or externally supplied signals and amplifies them to the level required to drive the horizontal deflection plates of the CRT. The interaction of these two systems deflects the CRT beam in a manner that results in a visual display of the waveform on the face of the CRT.

The sweep generator which is part of the horizontal deflection system provides a variable range of sweep times to enable the operator to display one or several cycles of the waveform as required. This range is from 0.1 usec per cm to 5 seconds per cm.

In addition to the main oscilloscope unit the plug-in units listed in table 1-1 are covered in this manual. These plug-in units are designed for quick and easy installation or removal. A single locking knob holds each unit securely in the oscilloscope. No tools are needed to change them, and less than a minute is required.

The calibrator, which is an integral part of the oscilloscope, provides a convenient means of checking horizontal and vertical deflection. The calibrator generates a controlled 1-kc square-wave output which can be displayed on the CRT screen and used as a standard for the oscilloscope.

Two identical test prods are supplied as standard oscilloscope equipment. Isolation networks are built into the probes to reduce the input loading effect of the oscilloscope. The nominal scope input of 1 megohm shunted by 30 pf is changed to 10 megohms shunted by 10 pf at the probe tip. This results in a voltage drop of 10 to 1 in the probe.

3-2. PREPARATION FOR USE.

Before attempting to operate the oscilloscope, familiarize yourself with the functions of all the front panel controls and connectors, as given in paragraph 3-3, and read the operating precautions given in paragraph 3-4. Then refer to figure 3-2 for the initial turn-on and operating procedure.

3-3. DESCRIPTION OF CONTROLS AND CONNECTORS.

The controls and connectors of the oscilloscope which are normally used by the operator are shown in figure 3-1 and are described in table 3-1. The numbers in figure 3-1 relate each control to the descriptive text in table 3-1 and do not indicate a preferred order of operation.

3-4. OPERATING PRECAUTIONS.

a. Do not apply more than 600 volts peak to either the vertical or horizontal input connector or to the test prods.

b. Prior to turn on, set the INTENSITY control fully counterclockwise to avoid excessive intensity and possible burning of the CRT screen during warm up.

c. Allow at least two inches of clearance at the rear and both sides of the oscilloscope so its forced air cooling system will operate efficiently. Prevent warm air exhausted by other instruments from entering the air intake at the rear of the cabinet.

d. Check the air filter often. Clean it before it restricts air flow. Clean by dipping in warm soapy water. Rinse and dry before replacing. The filter removes easily by lifting the element up in its housing and pulling the bottom outward.

3-5. OPERATING PROCEDURES.

Procedures for turning on the oscilloscope, checking oscilloscope performance and obtaining various modes of operation are given in figures 3-2, 3-3, tables 3-2, 3-3, and paragraphs 3-6 through 3-14.

3-6. PROCEDURE FOR TURNING ON OSCILLOSCOPE; COMPENSATING TEST PRODS AND MAKING INITIAL ELECTRICAL INSPECTION.

The procedure of table 3-2, used in conjunction with figure 3-2, gives step-by-step instructions for turning on the oscilloscope, checking its operation and making initial adjustments in preparation for viewing an input signal.

3-7. SELECTING AND SYNCHRONIZING THE SWEEP AND ITS MAGNIFICATION.

The procedure of table 3-3, used in conjunction with figure 3-3, gives step-by-step instructions for synchronizing the oscilloscope sweep with an external signal or the signal being viewed, and for obtaining single sweep displays.

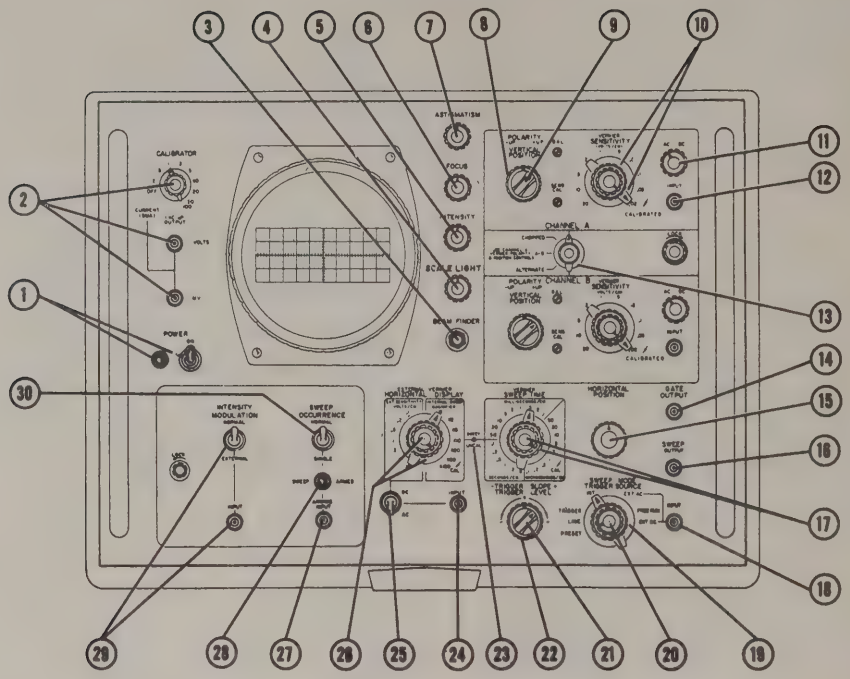


Figure 3-1. Oscilloscope Front-Panel Controls and Connectors

TABLE 3-1. DESCRIPTION OF FRONT-PANEL CONTROLS AND CONNECTORS (INDEX NUMBERS REFER TO FIGURE 3-1)

ITEM	DESCRIPTION AND FUNCTION
1	POWER Switch. In ON position, turns on all power to the oscilloscope; in off position, removes all power from oscilloscope. The adjacent indicator lamp is illuminated when the oscilloscope is turned on.
2	CALIBRATOR Switch and VOLTS-MV Connectors (type BNC). A 1-kc square wave calibration signal is provided at the VOLTS and MV connectors, with a peak-to-peak amplitude (in volts or millivolts depending on the connector used) corresponding to the CALIBRATOR switch position. With the CALIBRATOR switch set at CURRENT, a 1-kc square wave with 5 milliamperes peak current (with source impedance of 200K) is provided at the VOLTS connector.
3	BEAM FINDER Pushbutton. Used to locate off-screen traces when the oscilloscope beam has been driven off-screen. When this button is pressed, the beam is confined to the screen, brightened and defocused. Then the beam can be centered on the screen by adjusting the HORIZONTAL POSITION and VERTICAL POSITION controls while holding the BEAM FINDER pushbutton depressed. Release of the pushbutton returns the oscilloscope to normal functioning.
4	SCALE Control. Adjusts the brightness of the graticule illumination.
5	INTENSITY Control. Adjusts the brightness of the oscilloscope trace.
6	FOCUS Control. Adjusts the sharpness of the trace in conjunction with the ASTIGMATISM control.
7	ASTIGMATISM Control. Adjusts the sharpness of the trace in conjunction with the FOCUS control.
8	VERTICAL POSITION Control (black). Adjusts the vertical position of the Channel A presentation (Channel B has an identical control).
9	POLARITY Switch (red). Selects the direction of beam deflection for Channel A presentation; in + UP position, a positive signal deflects the beam upward (Channel B has an identical control).
10	SENSITIVITY Switch (black) and VERNIER Control (red). These controls select the sensitivity of the CHANNEL A input circuit. Each step of the switch is calibrated in VOLTS/CM of vertical deflection. With the VERNIER control in the CALIBRATED position, sensitivity exactly corresponding to the switch setting is provided. Turning the VERNIER control counterclockwise from the CALIBRATED position reduces the height of the displayed waveform and provides continuous adjustment of sensitivity between steps. (Channel B has identical controls.)
11	AC-DC Switch. Selects capacitive (AC) or direct (DC) coupling for the vertical input signal. Set to DC for viewing pulses longer than about .01 second or when the DC component of the signal is desired. Set to AC to avoid beam displacement due to DC voltage on signal (Channel B has an identical control).

TABLE 3-1 (Continued)

ITEM	DESCRIPTION AND FUNCTION
12	INPUT Connector (type BNC). Receives the input signal to Channel A (Channel B has an identical connector).
13	Vertical Presentation Selector Switch. Selects mode of CRT presentation of trace(s) from the dual-channel preamplifier: CHANNEL A only; CHANNEL B only; A–B (difference between Channel A and Channel B); ALTERNATE (Channel A and Channel B in sequence on alternate sweeps); CHOPPED (Channel A and Channel B on alternate 1-usec segments of each sweep).
14	GATE OUTPUT Connector (type BNC). Provides a +50-volt unblanking pulse during horizontal sweep time of trace. Connected to ground during retrace.
15	HORIZONTAL POSITION Control. Adjusts the horizontal position of the presentation.
16	SWEEP OUTPUT Connector (type BNC). Provides a ramp voltage (approximately -50 to +50 volts) which coincides with the internal horizontal sweep.
17	SWEEP TIME Switch (black) and VERNIER Control (red). These controls select the horizontal sweep rate. The switch is calibrated in 1-2-5 steps, in MICROSECONDS/CM, MILLISECONDS/CM, and SECONDS/CM. With the VERNIER control in the CAL (calibrated) position, the sweep rate corresponds exactly to the switch setting. Turning the VERNIER control counterclockwise from the CAL position slows the sweep and provides continuous adjustment of sweep rate between steps.
18	INPUT Connector (type BNC). Accepts an external sweep triggering signal.
19	TRIGGER SOURCE Switch (black). Selects source of the sweep triggering signal (power LINE, INTernal, EXTernal AC, or EXTernal DC).
20	SWEEP MODE Control (red). Provides a variable adjustment of the sensitivity of the sweep circuit to the trigger signal. Allows selection of either triggered or free running sweep by rotating the control pointer to either the left-hand (TRIGGER) or right-hand (FREE-RUN) sector. When turned fully counterclockwise to the PRESET position, provides greatest sensitivity and permits stable triggering with nearly all signals.
21	TRIGGER SLOPE Switch (red). Selects the portion of the triggering waveform which triggers the sweep: + (positive-going slope) or - (negative-going slope).
22	TRIGGER LEVEL Control (black). Selects the amplitude point on the input signal waveform at which the sweep will be triggered (range is ±30 volts from the center 0 position).
23	SWEEP UNCAL Indicator. Is illuminated when the combined settings of the SWEEP TIME and HORIZONTAL DISPLAY switches place the sweep at an uncalibrated speed.
24	INPUT Connector (type BNC). Accepts an externally applied horizontal input signal.
25	AC-DC Switch. Selects capacitive coupling (AC) or direct coupling (DC) for the external horizontal input signal. Set to DC for externally-driven sweep times longer than 1 millisecond or when the DC component of the signal is desired. Set to AC to avoid beam displacement due to DC voltage on signal.
26	HORIZONTAL DISPLAY Switch (black) and EXTERNAL VERNIER Control (red). Within its EXT SENSITIVITY sector, the switch selects the sensitivity of the horizontal input circuit to an external signal, in VOLTS/CM of horizontal deflection. With the EXTERNAL VERNIER control in the CAL position, sensitivity exactly corresponding to the switch setting is provided. Turning the EXTERNAL VERNIER control counterclockwise from the CAL position reduces the width of the displayed waveform and provides continuous adjustment of sensitivity between steps. Within its INTERNAL SWEEP MAGNIFIER sector, the HORIZONTAL DISPLAY switch in the X1 position selects the internal sweep as established by the SWEEP TIME switch. In the X2 through X100 positions, the HORIZONTAL DISPLAY switch expands the waveform presentation horizontally by a factor corresponding to its setting, by increasing the sweep speed a corresponding amount over that selected by the SWEEP TIME switch.
27	ARMING INPUT Connector (type BNC). Accepts the external signal which arms the internal sweep circuit to allow triggering of one sweep when the SWEEP OCCURRENCE switch is set to SINGLE. (The arming signal must be a pulse of +15 to +25 volts with a duration of 1 to 200 microseconds.)
28	SWEEP ARMED Indicator. Indicates that the sweep circuit is ready to be triggered by an external or internal pulse for a single sweep. Lamp extinguishes after sweep starts.
29	INTENSITY MODULATION Switch and INPUT Connector (type BNC). Selects NORMAL mode (no intensity modulation) or EXTERNAL modulation of trace intensity. INPUT connector is for the external intensity modulating signal; +20 volts will provide complete blanking of a trace of normal intensity.
30	SWEEP OCCURRENCE. Selects either NORMAL- or SINGLE-sweep operation.

CAUTION

For proper operation, both plug-in units must be pushed in firmly and locked in place with their LOCK knobs. Lock the knobs by turning toward the adjacent side of the instrument following the arrow on the panel.

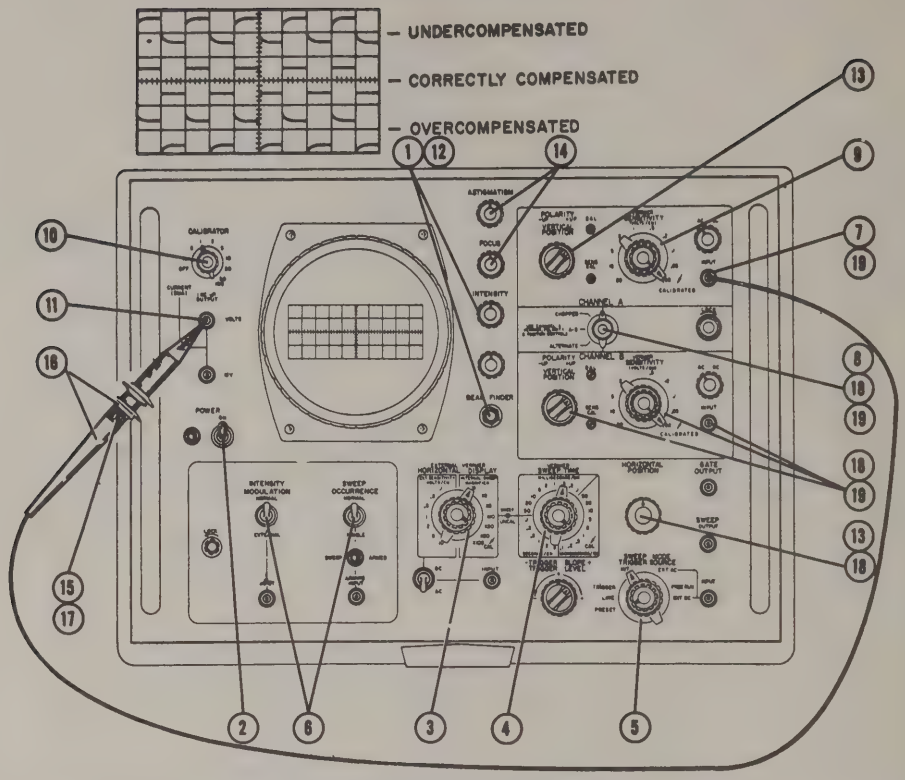


Figure 3-2. Procedure for Turning on Oscilloscope, Compensating Probe, and Making Initial Electrical Inspection

TABLE 3-2. PROCEDURE FOR TURNING ON OSCILLOSCOPE AND PREPARING IT FOR USE (STEP NUMBERS ARE KEYED TO INDEX NUMBERS ON FIGURE 3-2)

STEP	ACTION
1	Turn INTENSITY control fully counterclockwise.
2	Connect the oscilloscope to the 115-volt power source and switch POWER to ON. Allow five minutes warm up.
3	Set HORIZONTAL DISPLAY switch to X1; VERNIER control to CAL.
4	Set SWEEP TIME switch to .5 MILLISECONDS/CM.; VERNIER control to CAL.
5	Set SWEEP MODE control to PRESET; TRIGGER SOURCE switch to INT.
6	Set INTENSITY MODULATION and SWEEP OCCURRENCE switches to NORMAL.
7	Connect Test Prod BNC terminal to CHANNEL A INPUT connector.
8	Set Vertical Presentation Switch to CHANNEL A.
9	Set CHANNEL A SENSITIVITY switch to .05 VOLTS/CM.
10	Set CALIBRATOR switch to 2.
11	Connect Test Prod tip to CALIBRATOR VOLTS connector.
12	Rotate INTENSITY control clockwise until trace appears. If CRT remains blank, press BEAM FINDER button.

TABLE 3-2. (Continued)

STEP	ACTION
13	Adjust HORIZONTAL POSITION and CHANNEL A VERTICAL POSITION controls until trace is centered on screen. If necessary, readjust INTENSITY.
14	Adjust FOCUS and ASTIGMATISM controls to obtain a thin trace.
15	Loosen knurled locknut behind rear flange on prod.
16	Holding vinyl sheath behind locknut, rotate rear flange to obtain the best square wave (see insert). Check that vertical deflection is four centimeters (corresponding to .05 volts/cm sensitivity with 2 volts calibrator output and 10:1 attenuation in probe).
17	Tighten prod locknut without changing adjustment.
18	Turn Vertical Presentation Switch to CHANNEL B. Repeat the procedure of steps 9 through 17 for Channel B and the other test prod.
19	Repeat procedure with the Vertical Presentation Switch set to ALTERNATE and with both prods connected to the calibrator (one driving Channel A and one driving Channel B) to test both channels simultaneously.
20	The oscilloscope is ready for use. To display a single signal connect either probe to the signal and switch the Vertical Presentation Switch to the corresponding channel. Adjust the SENSITIVITY, HORIZONTAL DISPLAY and SWEEP TIME switches and the TRIGGER controls as necessary to obtain and synchronize the desired display. (Refer to table 3-3 and figure 3-3 for more detailed instructions.) For dual-trace operation and other specialized functions, refer to paragraphs 3-7 through 3-11.

3-8. HORIZONTAL DEFLECTION BY EXTERNAL SIGNALS.

After performing turn-on procedure in table 3-2, steps 1 through 14, connect the external signal to the Horizontal INPUT connector (24, figure 3-1) through either a test prod, a BNC-terminated coaxial cable, or plain wire leads with a BNC-to-binding post adapter. Then set the HORIZONTAL DISPLAY selector (26, figure 3-1) within its EXT SENSITIVITY sector to obtain the desired deflection in VOLTS/CM. To read the voltage of the horizontal deflection directly from the CRT trace, set the EXTERNAL VERNIER (26, figure 3-1) to CAL. Set the Input Coupling switch (25, figure 3-1) to AC or DC as required (refer to item 25, table 3-1).

3-9. DUAL-TRACE OPERATION.

Dual-trace operation is used to compare two different input signals, such as the input and output signals of an amplifier or network.

The vertical plug-in provides two types of dual-trace operation as selected by the Vertical Presentation Switch (13, figure 3-1): ALTERNATE and CHOPPED. On ALTERNATE operation, the output of one channel is shown on the CRT during one sweep and the output of the other channel during the next sweep. On chopped operation channels are switched at a one-megacycle rate, so both signals appear in alternate 1-microsecond segments during each sweep.

Alternate operation is for comparing two signals which require use of high sweep speeds. However, for most accurate time comparisons, the sweeps must be triggered by an external signal that is synchronized with both vertical signals. In many cases, one of the vertical signals can be used as the trigger signal as well (by making appropriate external connections). Internal triggering on the vertical signal cannot be used because of the instability that might be produced by the dual-channel display switching. When signal frequency permits, greater accuracy can be obtained by comparing the two signals during a single sweep, as made possible by chopped operation.

Chopped operation is for comparing two signals while using sweep speeds below about five microseconds/centimeter (which are low compared to the 1-megacycle switching rate). This type of operation permits precise time comparisons because both signals are displayed during the same sweep. In general, external triggering is required. If internal triggering is attempted, the one-megacycle switching signal may trigger the sweep and cause an unstable presentation.

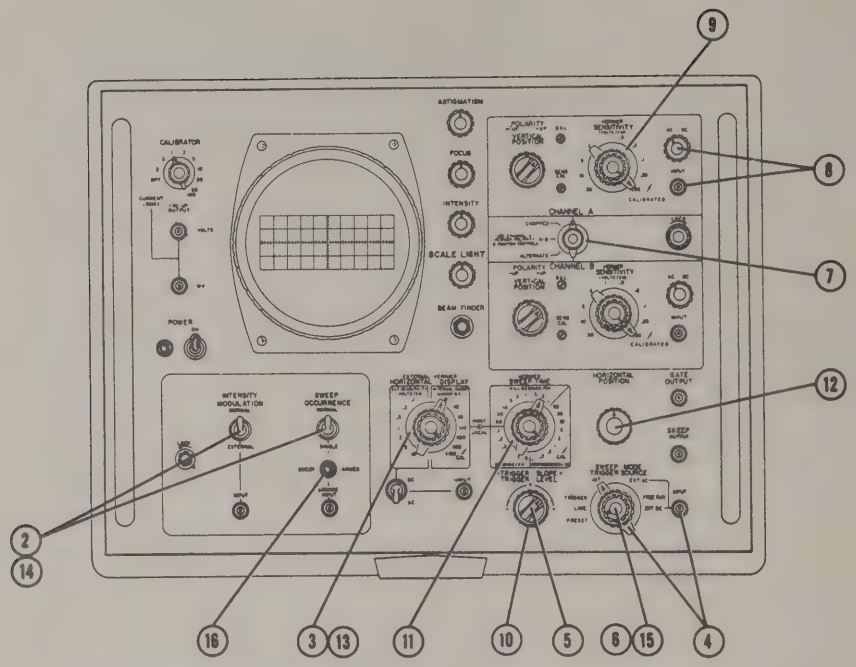


Figure 3-3. Selecting and Synchronizing the Sweep and Sweep Magnification

TABLE 3-3. SELECTING AND SYNCHRONIZING THE SWEEP AND SWEEP MAGNIFICATION
(STEP NUMBERS ARE KEYED TO INDEX NUMBERS ON FIGURE 3-3)

STEP	ACTION
1	Perform turn on procedure as described in steps 1-14 of figure 3-2 and table 3-2.
2	For normal operation with recurrent sweep, check that INTENSITY MODULATION and SWEEP OCCURRENCE switches are set to NORMAL.
3	Set HORIZONTAL DISPLAY switch to X1.
4	To provide for internal triggering from the vertical presentation waveform (normally used with single-channel or A-B differential display), set TRIGGER SOURCE switch to INT. If sweep is to be triggered by an external signal, connect signal to trigger INPUT connector and set TRIGGER SOURCE switch to EXT AC or EXT DC.
5	Set TRIGGER SLOPE switch to trigger on positive- or negative-going slope of the triggering signal as desired. When internal triggering is being used, reversing the POLARITY switch of the channel being monitored reverses the side of the wave that triggers the sweep in addition to inverting the display.
6	Set SWEEP MODE control to PRESET. For most sync signals and frequencies the PRESET SWEEP position gives stable synchronization.
7	Select CHANNEL A or CHANNEL B with Vertical Presentation Switch.
8	Connect signal which is to be checked to INPUT connector of channel selected, and set AC-DC switch for type of coupling desired.
9	Set SENSITIVITY switch for vertical deflection desired. To read voltage of vertical deflection, set VERNIER control to CALIBRATED.

TABLE 3-3. (Continued)

STEP	ACTION
10	Set SWEEP TIME switch for horizontal display desired. To read time from the horizontal deflection of the trace, set VERNIER control to CAL. Otherwise, set VERNIER control as desired to synchronize the sweep with the frequency of the vertical signal to produce a display containing a specific number of cycles or other desired features of the waveform.
11	Adjust TRIGGER LEVEL control to the voltage point on the waveform that should begin the sweep.
12	If necessary readjust SWEEP MODE and/or TRIGGER LEVEL controls to stabilize the sweep. When the trigger frequency is approximately 10 mc or higher, the FREE RUN position of the SWEEP MODE control may be the best position.
13	Adjust the HORIZONTAL POSITION control so that the portion of trace to be observed or magnified is under the center vertical line of graticule.
14	Set the HORIZONTAL DISPLAY switch to the desired degree of magnification. If combination of selected sweep and degree of magnification produces a sweep faster than 0.02 usec/cm, the SWEEP UNCAL indicator will light indicating that sweep time is no longer calibrated.
15	For observation of transient pulses and other signals that cannot use recurrent sweep, operate the oscilloscope in the single sweep mode as follows: Set the SWEEP OCCURRENCE switch to SINGLE. (Make all other vertical, horizontal, and trigger control settings as desired, in accordance with the previous directions.) Then apply a +15 to +25 volt (peak) pulse with a duration of 1 to 200 μsec to the ARMING INPUT connector, whenever a single sweep is desired. Once the circuit is armed, the next internal or external trigger pulse will trigger a sweep.
16	Arming can also be accomplished without applying an external pulse to the ARMING INPUT connector by use of the SWEEP MODE control. If the desired position of the SWEEP MODE control for proper triggering is outside the PRESET position, turn the SWEEP MODE control quickly to PRESET and back to the desired position to arm the sweep. If the desired position of the SWEEP MODE control is the PRESET position, momentarily switch the control out of PRESET and back to PRESET to arm the sweep. In either case, the next internal or external trigger pulse will trigger a sweep.
17	After an external arming pulse is received, or the SWEEP MODE control is switched as in step 16, the SWEEP ARMED indicator lights. This indicator extinguishes as sweep begins.

3-10. DIFFERENTIAL OPERATION.

Differential operation, as selected by the A-B position of the Vertical Presentation Switch (13, figure 3-1), permits observation of the difference between two signal voltages. It is useful for observing signals which are balanced with respect to ground.

In differential operation, ripple or stray pickup which is common to the two main signals is attenuated. With both the CHANNEL A and CHANNEL B SENSITIVITY switches (10, figure 3-1) set to .02 VOLTS/CM, common-mode signals are attenuated at least 100:1; with the SENSITIVITY switches at other settings, common-mode signals are attenuated at least 20:1. However, the amplitude of common-mode signals (before attenuation) should not exceed the equivalent of 100 centimeters of deflection. For example, if both SENSITIVITY switches are set to .02 VOLTS/CM, the common-mode signal should not exceed 2 volts (20 volts at probe input). Excessive common-mode signals overload the amplifiers, causing causing distortion.

When in differential operation, the most accurate difference signal and greatest common-mode rejection is obtained when the two input signals to the oscilloscope are balanced and both SENSITIVITY switches are set to the same setting.

During differential operation, the SENSITIVITY and the AC-DC Input Coupling switches (10 and 11, figure 3-1) of both channels operate on their respective signals; however, only the Channel A VERTICAL POSITION, POLARITY, and VERNIER controls (8, 9, and 10, figure 3-1) are effective.

3-11. SINGLE-SWEEP OPERATION.

Single-sweep operation is intended for viewing transients and other one-shot signals and aperiodic signals which cannot be viewed using normal recurrent-sweep operation. In single-sweep operation, the sweep generator is disabled at the end of each sweep and must be armed before it can generate another horizontal sweep trace. The sweep generator can be armed automatically with an external signal or manually with the SWEEP MODE control. Detailed instructions for single-sweep operation are given in steps 15 through 17 of table 3-3.

3-12. OPERATION WITH INTENSITY MODULATION.

First perform turn-on procedure in table 3-2. Then set INTENSITY MODULATION switch (29, figure 3-1) to EXTERNAL and connect the external signal to the Intensity Modulation INPUT connector just below the switch. A signal of +20 volts peak will blank the trace when the trace is set for average intensity. Negative voltages brighten the trace.

3-13. OPERATION WITH DIRECT CONNECTION TO CRT FOR VERTICAL DEFLECTION.

WARNING

Before making connections directly to the deflection plates of the CRT, disconnect the oscilloscope from the ac power source. The exposed terminals used for making direct-deflection connections operate at bias voltages of about 200 volts dc.

a. With power disconnected from the oscilloscope, remove the access plate on the top of the cabinet, which exposes the CRT direct deflection terminals as shown in figure 3-4.

b. Remove the leads from vertical deflection plate terminals D3 and D4.

c. Connect input coupling components to provide for input signal and bias voltage coupling as shown in figure 3-4. Use capacitors with good high-frequency response, such as C103 listed in table 6-2. With the bias connections shown, the front panel VERTICAL POSITION control remains effective.

d. For single-ended input, ground the common signal lead at the point shown by the dashed ground lead in figure 3-4. For balanced input, leave both signal leads ungrounded.

e. Connect the input power cord and turn the oscilloscope on. The procedures previously described for horizontal sweep operation can be used, except that an external signal must be used for triggering the sweep.

3-14. SUMMARY OF OPERATING PROCEDURES.

Refer to table 3-2 and figure 3-2 for a summary operating procedure. Summary information about the function of any particular control(s) can be found in table 3-1 which is keyed to control locations shown in figure 3-1.

3-15. TURN-OFF PROCEDURE.

When the oscilloscope is not being used but it is necessary to leave it turned on for instant service, rotate the INTENSITY control fully counterclockwise to extinguish the trace and prevent burning the CRT. At all other times, turn the intensity control fully counterclockwise and turn the POWER switch off to remove all power from the oscilloscope.

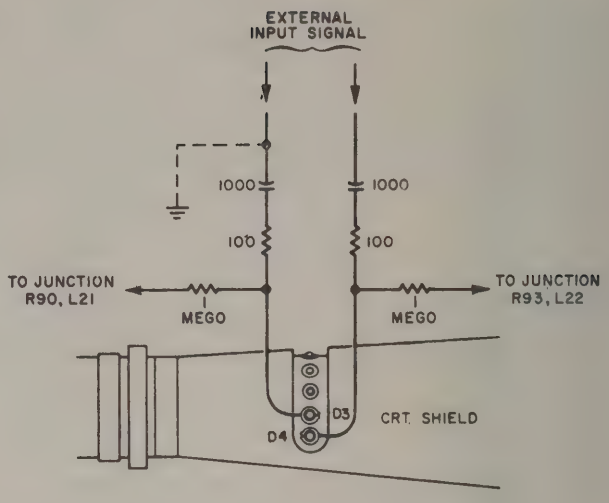


Figure 3-4. Connections for Direct Deflection Operation

3-16. OPERATOR'S MAINTENANCE.

Maintenance by operating personnel is limited to checking and adjusting vertical sensitivity and balance, cleaning the air filter, replacing fuses, or emergency replacement of electron tubes and semiconductors.

Fuses for the +110 volt and -100 volt power supplies, plus spare fuses for these supplies, are located at the rear of the horizontal plug-in compartment. Fuses for the +370 volt supply, 6.3 volt supply and the power line, plus a spare fuse for each, are located at the rear of the vertical plug-in compartment (see figure 5-11).

Localization of trouble to a particular electron tube or semiconductor often requires technical skill and use of trouble-shooting techniques. In many cases a calibration adjustment is required when a tube is replaced. Therefore, only a technician should replace tubes and semiconductors, except in an emergency.

3-17. OPERATING CHECKS AND ADJUSTMENTS.

The following tests show the operating condition of the oscilloscope. The checks consist of testing vertical and horizontal sensitivity calibration, and vertical balance. Vertical sensitivity calibration need be checked only occasionally under normal circumstances. However, if the oscilloscope is subjected to extreme environmental conditions or is to be used to the full extent of its rated accuracy, vertical sensitivity calibration should be checked each time the oscilloscope is put into operation.

a. VERTICAL SENSITIVITY CHECK.—Perform the turn-on procedure given in figure 3-2 and table 3-2, checking Channel A and Channel B in turn. If a test prod is used in this test, set the CALIBRATOR

switch to 2 and input sensitivity to .05 VOLTS/CM and if necessary, adjust the CHANNEL A SENS. CAL. (screwdriver adjustment on panel of Dual Trace Preamplifier) on the panel to obtain a square wave exactly 4 cm high. If a plain wire connection is used for the calibration voltage input, set the CALIBRATOR to .2 to produce the same deflection. Repeat the procedure for Channel B. If either channel cannot be adjusted to the proper sensitivity, the oscilloscope should be calibrated in accordance with the procedure given in Section 5.

b. BALANCE CHECK.—Balance is properly set if the presentation for either channel has no vertical shift when the sensitivity VERNIER control for that channel is rotated, or when the POLARITY switch is switched between + UP and - UP. The adjustment is not critical and need be set only when the shift is enough to be annoying. Proceed as follows:

(1) With the oscilloscope turned on, set the Vertical Presentation Switch to CHANNEL A and SWEEP MODE to FREE RUN.

(2) Adjust Channel A BAL (screwdriver adjustment on panel of Dual Trace Preamplifier) to obtain minimum vertical shift of trace as Channel A. POLARITY is switched between + UP and - UP.

(3) Repeat for Channel B.

c. HORIZONTAL SENSITIVITY CHECK.

(1) Connect VOLTS output of CALIBRATOR to INPUT connector of horizontal amplifier (24, figure 3-1) using a plain wire connection.

(2) Set CALIBRATOR switch to 5.

(3) Set the HORIZONTAL DISPLAY control to EXT., SENSITIVITY to 1 VOLTS/CM, and set the EXTERNAL VERNIER control to CAL.

(4) The trace should be deflected 5 centimeters ±0.25 cm. If the horizontal deflection is outside the above range, the oscilloscope should be calibrated in accordance with the procedure given in Section 5.

3-18. PREVENTIVE MAINTENANCE.

The air filter installed over the air intake on the rear of the cabinet prevents dust and dirt from entering the oscilloscope. The filter must be cleaned periodically so as not to restrict air flow into the cabinet. For the cleaning procedure, see paragraph 5-2a. The fan motor requires one drop of oil in each bearing once every six months, in continuous operation (see paragraph 5-2b).

WARNING

This instrument contains voltages as high as 8600 volts, which can cause death on contact. Turn the instrument off before touching any internal part.

3-19. EMERGENCY MAINTENANCE.

a. THERMAL SWITCH.—The oscilloscope has a thermal switch which opens the main power circuit if the temperature within the cabinet exceeds 140°F, ±5°F. If the instrument goes off during operation remove the Dual Trace Preamplifier plug-in with POWER still turned ON, and observe the neon lamp to the right of the fuse bracket inside the plug-in compartment. If the lamp is lit, the oscilloscope was overheated. Turn off the POWER switch, and investigate the cause of overheating. Be sure there is adequate clearance around the cabinet for the free circulation of air, that the air entering the cabinet is not preheated by recirculation, that the air filter is clean, and that the motor turns the fan at normal speed (approximately 2400 rpm). The thermal switch will automatically reclose the main power circuit when the temperature inside the cabinet returns to 120°F, ±5°F. Before returning the oscilloscope to service, be sure the fan is operating.

b. FUSE REPLACEMENT. —If the oscilloscope fails to operate when connected to a proper power source, check all fuses by substitution. (See paragraph 3-16 and figure 5-11 for fuse locations.)

c. EMERGENCY REPLACEMENT OF TUBES AND SEMICONDUCTORS.—In an emergency, operating personnel can replace tubes and semiconductors listed in table 3-2 without making the indicated adjustment. However, a technician should make the indicated adjustment as soon as possible after the replacement is made. In non-emergency conditions, tube replacement should be carried out as a part of systematic trouble shooting, following the procedure of Section 4. (See paragraph 5-2b for instructions for access to the oscilloscope chassis and figure 5-6 for an overall tube and semiconductor illustration.)

TABLE 3-4. ADJUSTMENTS REQUIRED FOLLOWING TUBE AND SEMICONDUCTOR REPLACEMENT

TUBE OR SEMICONDUCTOR	FUNCTION	ADJUSTMENT
Main Vertical Amplifier (Etched Circuit Assemblies A1 and A2; figures 5-14 and 5-15)		
V1	Cathode Follower	None
V2	Input Amplifier/Cathode Follower	Main Vertical Amplifier Gain and High Frequency Compensation (paragraph 5-4f)
V3	Input Amplifier/Cathode Follower	Main Vertical Amplifier Gain and High Frequency Compensation (paragraph 5-4f)
V4	Internal Trigger Amplifier/ Cathode Follower	None
V5	Internal Trigger Amplifier/ Cathode Follower	None
V6	Cathode Follower	None
V7	Constant Current Generator	None
V10	Cathode Follower	None
V11 through V13	Output Amplifier	Main Vertical Amplifier Gain and High Frequency Compensation (paragraph 5-4f)
Sweep Generator (Etched Circuit Assembly A101; figure 5-17)		
CR101	Clamp	None
CR102	Limiter	None
CR103	Limiter	None
CR104	Switch Diode	Sweep Time Calibration (paragraph 5-4e(2))
V101	Trigger Amplifier	Trigger Symmetry (paragraph 5-4e(1)
V103	Trigger Generator	None
V104	Gate Generator	Preset (paragraph 5-4e(1))
V105	Gate Generator/Clamp	Preset (paragraph 5-4e(1))
V107	Cathode Follower	None
V109	Integrator	Sweep Time Calibration (paragraph 5-4e(2))
V113	Bias Control Cathode Follower	None
V114	Cathode Follower	None
V115	Output Cathode Follower	None
Horizontal Amplifier (Etched Circuit Assemblies A202 and A203; figures 5-23 and 5-24)		
Q201/202	Differential Amplifier	All Horizontal Amplifier Adjustments (par. 5-4d)
V201	External Input Cathode Follower/Input Cathode Follower	External Vernier Balance (paragraph 5-4d(1))
V202	Cathode Follower	X100 Gain and Balance (paragraph 5-4d(2))
V203	Cathode Follower	None
V204/205	Differential Amplifier	All Horizontal Amplifier Adjustments (par. 5-4d)
V206	Output Cathode Follower	None
V207	Capacitance Driver	Capacitance Driver (paragraph 5-4d(3))

TABLE 3-4. (Continued)

TUBE OR SEMICONDUCTOR	FUNCTION	ADJUSTMENT
High Voltage Power Supply (Etched Circuit Assemblies A301 and A302; figures 5-26 and 5-27)		
V301	Amplifier	High Voltage, R321 (paragraph 5-4b)
V304	R.F. Oscillator	None
V305	CRT	All Main Vertical Amplifier and Horizontal Amplifier Adjustments (paragraphs 5-4d and f)
V308 through V311	Rectifier	None
Calibrator (Etched Circuit Assembly A301; figure 5-26)		
V306	Multivibrator	None
V307	Clamp Diode/Disconnect Diode	None
Low Voltage Power Supplies (Etched Circuit Assemblies A401 and A402; figures 5-28 and 5-29)		
CR401 through CR415	Rectifier	None
CR413	Reference Diode	None
CR414/415	Rectifier	None
CR416	Reference	6.3 Volt Supply (paragraph 5-4a(2))
Q401 through Q419	Amplifier, Emitter Followers, Regulators	None
V401	Voltage Regulator	-100 Volt Supply (paragraph 5-4a(1))
MX-2930A/USM Dual Trace Preamplifier (Etched Circuit Assemblies A501 and A502; figures 5-31 and 5-32)		
CR501 through CR506	Coupling, Clamp Diodes	None
Q501/502	Differential Amplifier	Sensitivity Calibration and Vernier Balance, Channel A (paragraphs 5-4g(1) and (2))
Q503/504	Differential Amplifier	Sensitivity Calibration and Vernier Balance, Channel B
V501	Cathode Follower	Vernier Balance, Channel A (paragraph 5-4g(1))
V502	Transistor Driver	Sensitivity Calibration and Vernier Balance, Channel A (paragraphs 5-4g(1) and (2))
V503	Output Cathode Follower	None
V504	Cathode Follower	Vernier Balance, Channel B (paragraph 5-4g(1))
V505	Transistor Driver	Sensitivity Calibration and Vernier Balance, Channel B (paragraphs 5-4g(1) and (2))
V506	Output Cathode Follower	None
V507	Amplifier/Cathode Follower	None
V508	Switching Multivibrator	Multivibrator Frequency (paragraph 5-4g(6))
MX-3078/USM Auxiliary Plug-In (figure 5-36)		
CR1	Limiter	None

SECTION 4

TROUBLE SHOOTING

4-1. INTRODUCTION.

This section contains information that can be used to quickly and efficiently locate and correct the cause of an equipment malfunction or performance degradation. The basic troubleshooting technique is based on the following six logical steps:

a. SYMPTOM RECOGNITION. — Not all malfunctions are immediately obvious in normal use, such as performance degradation. Such faults will be exposed, however, in the Reference Standards Procedures of Section 5. The technician should be critical of any variation in equipment performance to indicate the "not so apparent" malfunctions.

b. SYMPTOM ELABORATION. — When a malfunction is suspected, the technician should test all performance characteristics to gain as much information as possible about the oscilloscope performance. When all the information is collected about the response to front-panel controls, CRT display behavior, etc., it will then be easier to localize the faulty section.

c. DETERMINING PROBABLE FAULTY SECTION. — A thorough understanding of the principles of operation of the oscilloscope, which are included in this section, will help the technician to make a logical choice as to which circuit or section could cause the improper performance. In most cases it is a good procedure to "think through" or list the faulty sections stage by stage before proceeding with trouble shooting. This Troubleshooting Section is arranged with a separate theory description and troubleshooting procedures for each major section, including functional and servicing block diagrams, to aid in understanding individual circuits and localizing troubles to them.

d. LOCATING THE FAULTY FUNCTION. — Refer to the list of probable faults made in step c and, if necessary, arrange them into the most efficient testing order. The troubleshooting procedures in this section are designed to isolate tests to the major sections of the oscilloscope.

e. LOCALIZING THE FAULTY CIRCUIT. — When the faulty major section has been isolated, there still remain several possibilities of faulty circuits within that section.

f. FAILURE ANALYSIS. — When the faulty circuit or component has been discovered, it is important to review the steps that led to its discovery to determine where the primary fault may be. For example, a faulty vacuum tube may have been caused by an undiscovered shorted capacitor in its circuit. Any additional information about the circuit performance gathered at the very beginning of the troubleshooting procedure can be very useful now. This review is necessary to make certain that the discovered fault is the cause and not the result of the malfunction.

g. TEST EQUIPMENT REQUIRED FOR TROUBLE SHOOTING. — Table 4-1 lists the test equipment required for trouble shooting.

4-2. OVERALL OSCILLOSCOPE.

a. FUNCTIONAL DESCRIPTION OF OSCILLOSCOPE. — The oscilloscope produces a graphical picture of applied voltage variations on the face of a CRT. Figure 4-1 is an overall functional block diagram of the oscilloscope. The functional sections are:

(1) Low-Voltage Power Supply
(2) High-Voltage Power Supply
(3) Beam Finder Circuit
(4) Main Vertical Amplifier
(5) Horizontal Amplifier
(6) Sweep Generator
(7) MX-3078/USM Horizontal Plug-In
(8) Calibrator Circuit
(9) MX-2930B/USM Vertical Plug-In

b. LOW-VOLTAGE POWER SUPPLIES. — The low-voltage power supplies provide the voltages required by the oscilloscope and plug-in units. All DC voltages provided by the supplies (except to the fan) are regulated.

c. HIGH-VOLTAGE POWER SUPPLY. — The high-voltage power supply generates the high voltages required for operation of the CRT.

d. BEAM FINDER CIRCUIT. — The beam finder circuit intensifies and centers the CRT display so that "lost" traces may be located and adjusted.

e. MAIN VERTICAL AMPLIFIER. — The main vertical amplifier amplifies the signals received from the vertical plug-in and applies the signals to the vertical deflection plates of the CRT. The main vertical amplifier also applies a synchronization signal derived from the vertical input signal to the sweep generator for internal triggering of the sweep.

f. HORIZONTAL AMPLIFIER. — The horizontal amplifier converts the sweep or external horizontal signal to a balanced signal, amplifies it, and applies it to the horizontal deflection plates of the CRT.

g. SWEEP GENERATOR. — The sweep generator generates a linearly rising voltage to sweep the CRT beam horizontally across the CRT screen. The sweep generator thus provides a linear time base on which to display the vertical signals. The generator can be operated as a triggered or free-running circuit. A delay line (0.2 microsecond) is provided within the main vertical amplifier to delay the displayed signal long enough to allow the sweep generator to be triggered before the signal appears on the CRT.

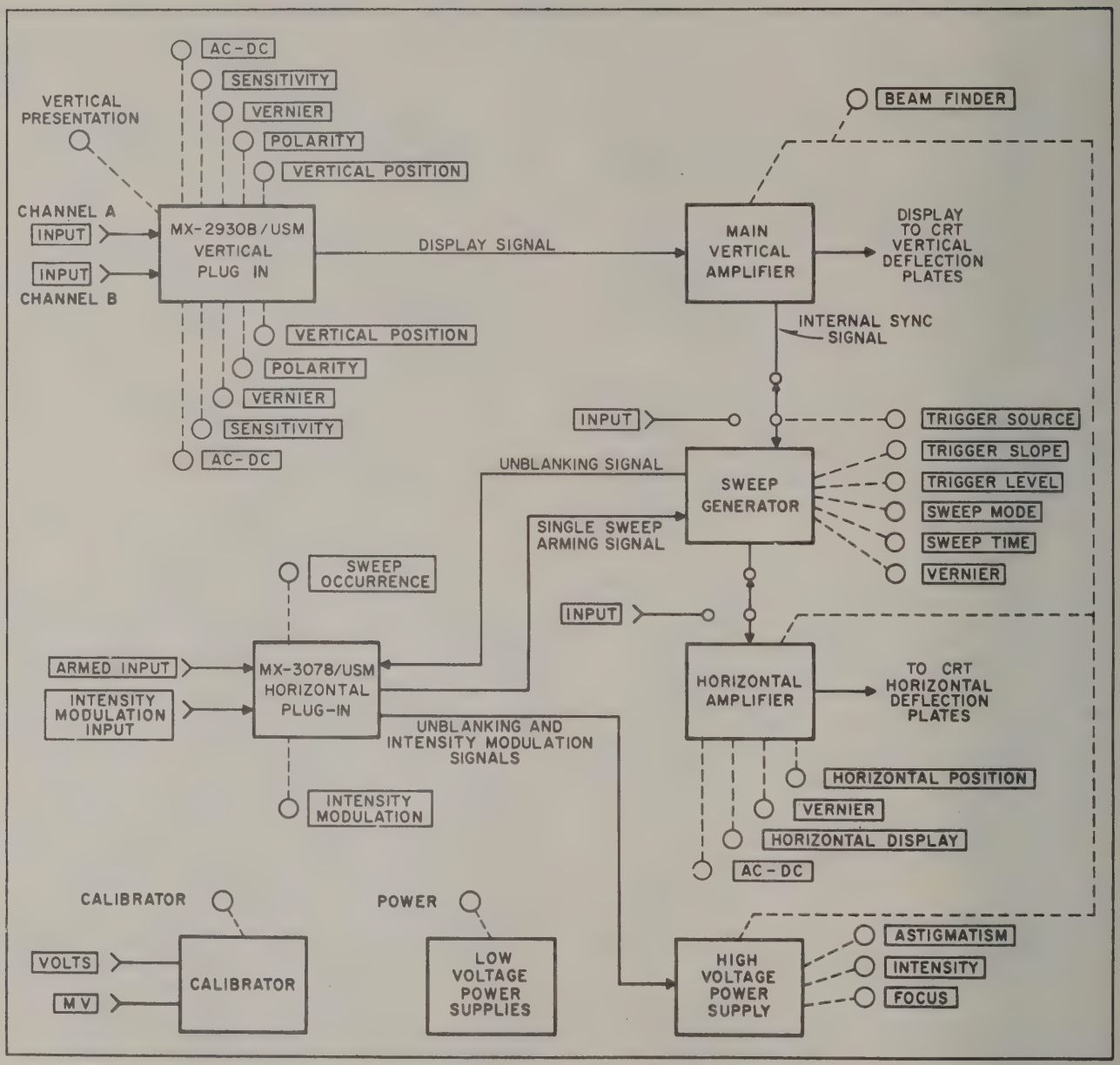


Figure 4-1. Overall Functional Block Diagram

h. MX-3078/USM HORIZONTAL PLUG-IN. — The horizontal plug-in unit makes provision for single-sweep operation and for external intensity modulation.

i. MX-2930B/USM VERTICAL PLUG-IN. — This Dual Trace Preamplifier plug-in unit receives the two separate vertical input signals and provides separate attenuation or preamplification as required, with separate sensitivity, positioning, and polarity controls for each channel. This plug-in unit can provide for the following display modes: one signal only, two signals displayed on alternate sweeps, two signals chopped for display on the same sweep, or a difference signal resulting from the subtraction of two signals. In any of these modes, after making the appropriate signal combination, the unit converts the signal into balanced form and applies it to the input of the main vertical amplifier.

j. CALIBRATOR CIRCUIT. — The calibrator circuit generates a 1-kilocycle square wave for checking the calibration of the vertical and horizontal amplifiers and for compensating for test prods.

4-3. OVERALL OSCILLOSCOPE TROUBLE SHOOTING

Before attempting any trouble-shooting procedure, first make an overall preliminary check of the equipment. Look for external defects such as a dirty filter, broken or loose controls, damaged CRT or graticule, and damaged input connectors. Then remove the cabinet following the directions in paragraph 5-2b, and with power removed, check for broken or bulging components, loose tubes, and frayed wiring. If this check does not reveal any fault, proceed with the following tests.

a. TEST EQUIPMENT AND SPECIAL TOOLS. Test equipment required for trouble shooting is listed in table 4-1. No special tools are required.

b. TROUBLE-SHOOTING PROCEDURE. A procedure for trouble-shooting the over-all oscilloscope is given in table 4-2. This procedure utilizes CRT presentations in response to particular control settings as a means of localizing trouble. Where improper presentations are obtained, table 4-2 directs the technician to a probable circuit or section of the oscilloscope which deserves a more detailed check. Further checking can then be performed by referring to the trouble-shooting text and servicing block diagram for the circuit concerned in this section of the manual, where test voltages and other trouble-shooting data are presented. Test voltages are also given on the schematic diagrams in Section 5.

c. SERVICING BLOCK DIAGRAM. A servicing block diagram for the over-all oscilloscope is shown in figure 4-2. This diagram provides an alternate means of trouble-shooting by measuring waveforms at various test points as shown. Physical locations of the test points referenced in all servicing block diagrams and schematics are shown in figures 4-14 through 4-22.

TABLE 4-1. TEST EQUIPMENT REQUIRED FOR TROUBLE SHOOTING

DESIGNATION	NAME
AN/USM-98	DC Voltmeter
AN/USM-116	High-Voltage Voltmeter
ME-6/U	AC Voltmeter
AN/URM-90	Q Meter
AN/USM-108	Time-Mark Generator
Model 107	Square Wave Generator (Tektronix)
AN/USM-140B with AM-3567/USM	Oscilloscope with High-Gain Differential Amplifier Plug-In

NOTE: See table 1-2 for full description.

CAUTION

If any tubes are replaced as a part of trouble shooting, circuit adjustments may be required before the oscilloscope can be operated. Refer to table 3-4 for a complete listing of tubes and the adjustments required when certain tubes are replaced. Tube locations are shown in figure 5-6.

TABLE 4-2. OVER-ALL OSCILLOSCOPE TROUBLE SHOOTING

STEP	ACTION	RESULTS	NEXT STEP
1	Connect oscilloscope to power source and turn the POWER switch ON.	POWER ON indicator lights and fan operates.	4
		POWER ON indicator lights and fan doesn't operate.	2
		If both POWER ON indicator and fan don't operate, check line fuses F401 and F402, the power cable, and the power switch.	
2	Check overheat indicator behind vertical plug-in unit.	If indicator is on, thermal relay has turned power off. Remove the cause of overheating.	
		Indicator light is off.	3
3	Check ±6.3 volts supply fuse F406 behind vertical plug-in unit.	If fuse F406 is good, check the fan.	
		If fuse is faulty, replace F406, and then refer to the trouble-shooting procedures for the ±6.3 volt supply in the low-voltage power supply.	
4	Set the INTENSITY FOCUS, ASTIGMATISM controls for a clear bright spot or trace. Use the BEAM FINDER HORIZONTAL and VERTICAL POSITION controls to center the trace.	Clear bright trace appears on screen.	5
		Blurred spot appears when BEAM FINDER pressed but can't be centered. Note whether offset is vertical or horizontal, then refer to the trouble-shooting procedures for the vertical or horizontal amplifiers.	
		If trace appears only when the BEAM FINDER is pressed and the INTENSITY set fully clockwise, check the V107 circuit in the sweep generator.	
		If nothing appears on the CRT screen with the BEAM FINDER pressed and the INTENSITY set fully clockwise, refer to the low- and high-voltage power supply trouble-shooting procedures. Also check the output stages of the vertical and horizontal amplifiers, or the CRT.	

TABLE 4-2. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
5	Set Channel A SENSITIVITY to .02, CALIBRATOR to 100, SWEEP TIME to .5 MILLISECONDS/CM, and the TRIGGER SOURCE to INT. Connect CALIBRATOR MV OUTPUT to the Channel A INPUT. Set the SWEEP MODE to FREE RUN then to PRESET. Repeat for Channel B.	Square wave appears on CRT on both free-running and preset sweep.	6
		If only one channel of dual channel amplifier functions normally, check faulty channel.	
		If little or no deflection from either channel of dual channel amplifier, refer to trouble-shooting procedures for main vertical amplifier, dual channel plug-in unit, and calibrator.	
		If presentation is unstable or present only with SWEEP MODE set to FREE RUN, check the trigger circuits, including V3, V4, and V5 in the main vertical amplifier, and V101 and V103 in the sweep generator.	
		If sweep appears far out of calibration, check sweep calibration or calibrator frequenty.	
		If both vertical sensitivity and sweep appear far out of calibration, check all DC supply voltages.	
6	Leave control settings and connections as in step 5 above, except set Vertical Presentation Switch to CHOPPED and then to ALTERNATE.	Dual channel presentation on CRT. Normal operation on steps 5 and 6 indicates all major circuits are operating. Rotate switches and controls to check all possibilities.	
		If dual channel presentation occurs on CHOPPED only, check V507 circuit in dual channel plug-in unit.	
7	Disconnect dual trace amplifier by sliding it partially out of oscilloscope.	If sweep is approximately centered vertically ±2 cm, check the dual channel plug-in unit.	
		If sweep remains vertically offset, check the main vertical amplifier.	

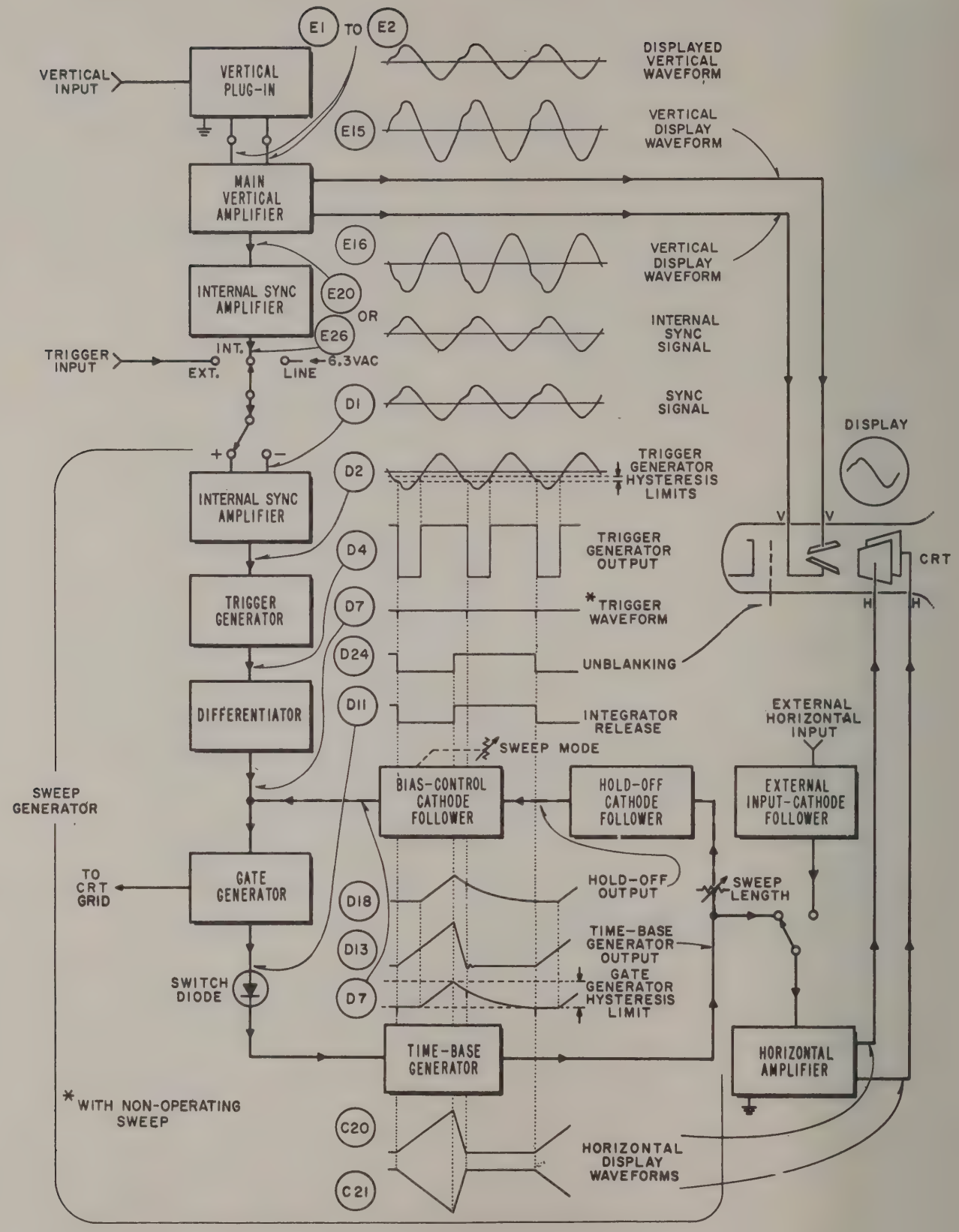


Figure 4-2. Overall Servicing Block Diagram

4-4. LOW-VOLTAGE POWER SUPPLY.

a. LOW-VOLTAGE POWER SUPPLY FUNCTIONAL DESCRIPTION. The low-voltage power supply section is a group of regulated DC supplies consisting of four voltageregulator circuits on one etched circuit assembly (A402) which are powered by four sets of solid-state rectifiers on a separate etched circuit assembly (A401). The Low-Voltage Power Supply Functional and Servicing Block Diagram, Figure 4-3, shows the functional relationship of all circuits in the low-voltage power supply and gives test points and voltages as an aid in trouble shooting. The four regulator circuits supply 12.6 volts, -100 volts, +110 volts, and +260 volts. The output of the +260 volt regulator is connected in series with the output of the +110 volt regulator in order to supply +370 volts. Each supply has an adjustment potentiometer to set its output voltage accurately; however, the -100 volt supply must be set first as its output voltage is used as a reference voltage for the +110 and +370 volt supplies and as an operating voltage in the 12.6 volt supply. The -100 volt supply uses a type 5651 gas regulator tube for its reference voltage; the 12.6 volt supply uses a breakdown diode to supply its reference voltage.

All four regulators operate in the same manner. In each regulator, a series regulator transistor (such as Q413 in the -100 volt supply) acts as an adjustable resistance in series with the load. A comparison amplifier (such as Q410 and Q411 in the -100 volt supply) compares a sample of the regulator output voltage (obtained from R450 and R451 in the -100 volt supply) against a stable reference voltage (obtained from V401 in the -100 volt supply). Any DC shift or AC ripple in the output voltage is amplified and applied to the base of the series regulator transistor. The signal is applied to the base with the proper polarity and amplitude to instantly adjust the resistance of the series element to counteract the initial change in output voltage and hold the output constant.

The 12.6 volt supply provides DC current for all tube heaters. The supply is ungrounded, and the heaters are connected in two equal-current parallel strings. The two strings are connected in series, the mid point is grounded, and the ends are connected across the 12.6 volt supply. Correct voltage adjustment consists of setting the 12.6 volts exactly and making sure that the voltages across the two strings are equal to within ±0.2 volts. A greater inequality means that some tube heater is open or shorted, or that an improper type of tube has been installed.

b. LOW-VOLTAGE POWER SUPPLY TROUBLE SHOOTING. Trouble symptoms in any of the low-voltage power supplies can be divided into four classes: (1) no output; (2) high or low output voltage that cannot be adjusted to proper value; (3) output voltage that does not remain constant as the line voltage is varied ±10% from 115 volts; and (4) a ripple level on the output that is greater than specified. Table 4-3 is a trouble-shooting chart for the low-voltage power supply. The step-by-step procedure given in table 4-3 is based on the trouble shooting techniques discussed below.

Since the four regulator circuits are interdependent, the first step in trouble shooting is to determine which supply is faulty, and the first supply to check is the -100 volt supply, since it serves as a reference for the other supplies. This is done by measuring the -100 volt supply first to be sure it operates properly, and then proceeding with the 12.6 volt supply, +110 volt supply and the +370 volt supply in that order. First measure the DC output voltage of the regulator under test, then adjust the line voltage ±10% while making the same measurement, to assure that the regulator operates properly when exposed to line voltage variations. Next measure the ripple level on the output of the regulator (with an oscilloscope), and then adjust the line voltage ±10% while repeating the same measurement. These measurements will identify the trouble symptom; and the trouble can be further localized by following subsequent steps of the trouble-shooting chart.

The cause of the symptoms of high and low output voltage and poor regulation are most often located by measuring the DC voltages at the transistor elements and comparing them with the voltages given on the block diagram (figure 4-3) and the schematic diagram (figure 5-44). Because of the large degree of degenerative feedback in each regulator circuit, some trouble symptoms may be difficult to isolate. For such cases, an additional set of voltages is given in parentheses on both the block and schematic diagrams. These voltages are taken with the feedback loop opened in the one supply being measured. The feedback loop in each regulator is opened by disconnecting the lead from the regulator circuit on the etched board to the base of the associated transistor mounted on the fan shroud as specified in the block and schematic diagram notes. The leads to the transistors mounted on the fan shroud are shown in detail in figure 4-20. Within each supply, the leads connect as follows: to test point A29 in the 12.6 volt supply, A9 in the -100 volt supply, A16 in the +110 volt supply, and A22 in the +370 volt supply.

To better understand the symptom of high ripple level in the output voltage of a power supply regulator, consider that the complete circuits consist of the DC power source (rectifiers and filter), complete regulator circuit, and the load. The ripple level across the load is equal to the ripple level across the DC power source minus the ripple level across the series regulator. The ripple across the series regulator is a function of the DC gain of the regulator amplifier. The ripple level across the DC power source is a function of the line voltage, the filter capacity, and the inductance that follows the rectifiers. An increase in ripple can be caused by a loss in gain in the regulator amplifier (which would also cause a loss of DC regulation), or it could be caused by a loss in capacity or inductance in the input filter (which may not be accompanied by a loss of DC regulation), or it may be caused by a large undesired increase in load current resulting from a short circuit. Ripple voltage measurement tests are included in the trouble-shooting chart, table 4-3, and are also indicated in tabular form, keyed to test points, on both the block and schematic diagrams. Test point locations are shown in figure 4-14.

USEFUL ILLUSTRATIONS OF THE LOW-VOLTAGE POWER SUPPLY

Illustration	Figure No.	Page No.	Illustration	Figure No.	Page No.
Block Diagram	4-3	4-13, 4-14	Location of Parts	4-20	4-53
Location of Test Points	4-14	4-47		5-28	5-46
				5-29	5-47, 5-48
			Schematic Diagram	5-44	5-73, 5-74

TABLE 4-3. LOW-VOLTAGE POWER SUPPLY TROUBLE SHOOTING

STEP	ACTION	RESULTS	NEXT STEP
1	Measure the DC voltages and AC ripple (peak-to-peak amplitude and frequency) at the supply outputs (test points A1 through A5) with the line voltage at 115 volts, 103 volts, and 127 volts.	One or more incorrect DC voltages which cannot be adjusted to correct value	2
		DC voltages good, but excessive ripple present on one or more supplies	3
2	Measure DC voltage at:		
	A1	Not +6.3 volts	4
	A2	Not -6.3 volts	4
	A3	Not -100 volts	14
	A4	Not +110 volts	23
	A5	Not +370 volts	32
3	Set SWEEP MODE just out of PRESET. Measure peak-to-peak ripple between:		
	*A1-A2 (±6.3V)	More than about 2.5 mv peak-to-peak	11
	A3-GND (-100V)	More than about 2 mv peak-to-peak	20
	A4-GND (+110V)	More than about 4.5 mv peak-to-peak	29
	*A4-A5 (+370V)	More than about 7 mv peak-to-peak	37
	*Differential oscilloscope (AN/USM-140B with AM-3567/USM plug-in) required for these measurements.		
	±6.3 VOLT SUPPLY		
4	Check fuse F406 and replace if faulty.	Voltages at A1 and A2 return to ±6.3 volts	1
		If replacement fuse blows, check fan motor and check for short between +6.3 and -6.3 busses.	
		Voltage between A1 and A2 is correct (12.6 volts) but is not approximately balanced to ground	5
		Fuse not faulty	6
5	Measure DC voltage between test points A2 and H1 (filament circuit) and between A3 and H2.	Voltage correct (about 0.04 volt)	10
		Voltage incorrect	6

TABLE 4-3. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
6	Measure DC voltage between test points A1 and A30.	Voltage correct (about 18 volts)	7
		If voltage is not about 18 volts, check CR414, CR415, L406, or ±6.3 volt supply load.	
7	Pull off base lead of Q416 and measure DC voltage at test points A1 and A2.	Voltages correct (A1 = +5.5 volts; A2 = -5.5 volts)	8
		Voltages incorrect	9
8	With Q416 base lead still off, measure DC voltage at test point A29.	If voltage is correct (about -12.6 volts), check Q415.	
		If voltage is incorrect, check Q414.	
9	With Q416 base lead still off, measure DC voltage at test point A30.	If voltage is correct (about -12.5 volts), check CR414 and CR416.	
		If voltage is incorrect, check Q416 and Q417.	
10	Check voltage drops between test points A2/A3 and all H test points shown on filament schematic diagram.	Incorrect voltages will point to group of tubes causing unbalance. Replace tubes to correct unbalance.	
11	Measure AC voltage between test points A30 and A1 with differential oscilloscope (AN/USM-140B with AM-3567/USM Plug-In).	Peak-to-peak voltage is less than about 1.2 volts	12
		If ripple is greater than about 1.2 volts, and frequency is 60 cps, check CR414 and CR415.	
		If ripple is high and 120 cps, check C425, L406, CR414, CR415, or load on ±6.3 volt supply.	
12	Measure AC voltage between test points A27 and A28.	Peak-to-peak voltage is at least 30 times that measured in step 3 (typically 75 mv)	13
		If AC voltage is much less than 30 times that measured in step 3, check Q414 and CR416.	
13	Measure AC voltage between test points A28 and A30.	If AC voltage is much less than 16 times that measured in step 12 (typically 1.2 volts), check Q415, Q416, and Q417.	
	-100 VOLT SUPPLY		
14	Check fuse F405 and replace if faulty.	Voltage at A3 returns to -100 volts	1
		Replacement fuse blows	15
		Fuse not faulty	17
15	Turn instrument off. Disconnect white/violet lead from test point A3. Measure resistance to ground from test point A3 and from white/violet lead.	If resistance at A3 is less than about 13K ohms, check load on -100V supply for shorts.	
		If resistance at white/violet lead is less than about 2000 ohms, check for short within the -100V supply.	
		Both resistances normal	16

TABLE 4-3. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
16	Connect dummy loads to -100 volt, +110 volt, and +370 volt supplies as follows: connect a resistance of 165 ohms (75 watts) between ground and white/violet lead removed from test point A3. Disconnect white/orange lead from test point A4, and connect a resistance of 125 ohms (150 watts) between ground and white/orange lead. Disconnect white/red lead from test point A5, and connect a resistance of 1160 ohms (150 watts) between ground and white/red lead. Turn instrument ON.	If voltage at test point A3 returns to -100 volts, check load for shorts.	
		If F405 blows again, check for short in -100 volt supply.	
17	Pull off base lead of Q413 and measure DC voltage at test point A3.	Voltage correct (about -52 volts)	18
		Voltage incorrect	19
18	With Q413 base lead still off, measure DC voltage at test point A8.	If voltage is correct (about -57 volts), check Q412.	
		If voltage is incorrect, check Q410 and Q411.	
19	With Q413 base lead still off, measure DC voltage at test point A11.	If voltage is correct (about -143 volts), check diodes CR409 through CR412, or -100 volt supply load.	
		If voltage is incorrect, check Q413 and Q419.	
20	Measure AC voltage between test point A11 and ground.	Peak-to-peak voltage is less than about 8 volts	21
		If ripple is greater than about 8 volts and frequency is 60 cps, check diodes CR409 through CR412.	
		If ripple is high and 120 cps, check C416, C420, L404, L405, CR409 through CR412, or load on -100V supply.	
21	Measure AC voltage between test points A6 and A9 with differential oscilloscope (AN/USM-140B with AM-3567/USM Plug-In).	Peak-to-peak voltage is at least 1.5 times that measured in step 3 (typically 3 mv)	22
		If AC voltage is much less than 1.5 times that measured in step 3, check Q410, Q411, and Q412.	
22	Measure AC voltage between test points A9 and A11.	If AC voltage is much less than 2500 times that measured in step 21 (typically 8 volts), check Q413 and Q419.	
	+110 VOLT SUPPLY		
23	Check fuse F404 and replace if faulty.	Voltage at A4 returns to normal	1
		Replacement fuse blows	24
		Fuse not faulty	26

TABLE 4-3. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
24	Turn instrument off. Disconnect white/orange lead from test point A4. Measure resistance to ground from test point A4 and from white/orange lead.	If resistance at A4 is less than about 55K ohms, check load on +110 volt supply for shorts.	
		If resistance at white/orange lead is less than about 3000 ohms, check for short within the +110 volt supply.	
		Both resistances normal	25
25	Connect dummy loads to +110 volt, -100 volt, and +370 volt supplies as follows: connect resistance of 125 ohms (150 watts) between ground and white/orange lead removed from test point A4. Disconnect white/violet lead from test point A3, and connect resistance of 165 ohms (75 watts) between ground and white/violet lead. Disconnect white/red lead from test point A5, and connect resistance of 1160 ohms (150 watts) between ground and white/red lead.	If voltage at A4 returns to +110 volts, check load for shorts. If F404 blows again, check for short in +110 volt supply.	
26	Pull off base lead of Q409 and measure DC voltage at test point A4.	Voltage correct (about +80 volts)	27
		Voltage incorrect	28
27	With Q409 base lead still off, measure DC voltage at test point A15.	If voltage is correct (about -10 volts), check Q408.	
		If voltage is incorrect, check Q406 and Q407.	
28	With Q409 base lead still off, measure DC voltage at test point A18.	If voltage is correct (about -16 volts), check diodes CR405 through CR408, or +110 volt supply load.	
		If voltage is incorrect, check Q418.	
29	Measure AC voltage between test points A18 and A4 with differential oscilloscope (AN/USM-140B with AM-3567/USM Plug-In).	Peak-to-peak voltage is less than about 11 volts	30
		If ripple is greater than about 11 volts, and frequency is 60 cps, check diodes CR405 through CR408.	
		If ripple is high and 120 cps, check C408, C411, L402, L403, CR405 through CR408, or load on +110 volt supply.	
30	Measure AC voltage between test points A13 and A16.	Peak-to-peak voltage is at least 4 times that measured in step 3 (typically 20 mv)	31
		If AC voltage is much less than 4 times that measured in step 3, check Q406, Q407, and Q408.	
31	Measure AC voltage between test points A16 and A18.	If AC voltage is much less than 500 times that measured in step 30 (typically 10 volts), check Q409 and Q418.	

TABLE 4-3. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
		+370 VOLT SUPPLY	
32	Check fuse F403 and replace if faulty.	Voltage at A5 returns to normal	1
		Replacement fuse blows	33
		Fuse not faulty	35
33	Turn instrument off. Disconnect white/red lead from test point A5. Measure resistance to ground from test point A5 and from white/red lead.	If resistance at A5 is less than about 17K ohms, check load on +370 volt supply for shorts.	
		If resistance at white/red lead is less than about 13K ohms, check for short within the +370 volt supply.	
		Both resistances normal	34
34	Connect dummy loads to +370 volt, -100 volt, and +110 volt supplies as follows: connect resistance of 1160 ohms (150 watts) between ground and white/red lead removed from test point A5. Disconnect white/violet lead from test point A3, and connect resistance of 165 ohms (75 watts) between ground and white/violet lead. Disconnect white/orange lead from test point A4, and connect resistance of 125 ohms (150 watts) between ground and white/orange lead.	If voltage at A5 returns to +370 volts, check load for shorts.	
		If F403 blows again, check for short in +370 volt supply.	
35	Pull off base lead of Q405 and measure DC voltage at test point A5.	If voltage is correct (about +320 volts), check Q401 or Q402.	
		Voltage incorrect	36
36	With Q405 base lead still off, measure DC voltage at test point A25.	If voltage is correct (about -15 volts), check diodes CR401 through CR404, or +370 volt supply load.	
		If voltage is incorrect, check Q403, Q404, and Q405.	
37	Measure AC voltage between test points A25 and A5 with differential oscilloscope (AN/USM-140B with AM-3567/USM Plug-In).	Peak-to-peak voltage is less than about 11 volts	38
		If ripple is greater than about 11 volts, and frequency is 60 cps, check diodes CR401 through CR404.	
		If ripple is high and 120 cps, check C401, C403, CR401 through CR404, or load on +370 volt supply.	
38	Measure AC voltage between test points A20 and A22.	Peak-to-peak voltage is at least 0.8 times that measured in step 3 (typically 10 mv)	39
		If AC voltage is much less than 0.8 times that measured in step 3, check Q401 and Q402.	
39	Measure AC voltage between test points A22 and A25.	If AC voltage is much less than 1000 times that measured in step 38 (typically 11 volts), check Q403, Q404, and Q405.	

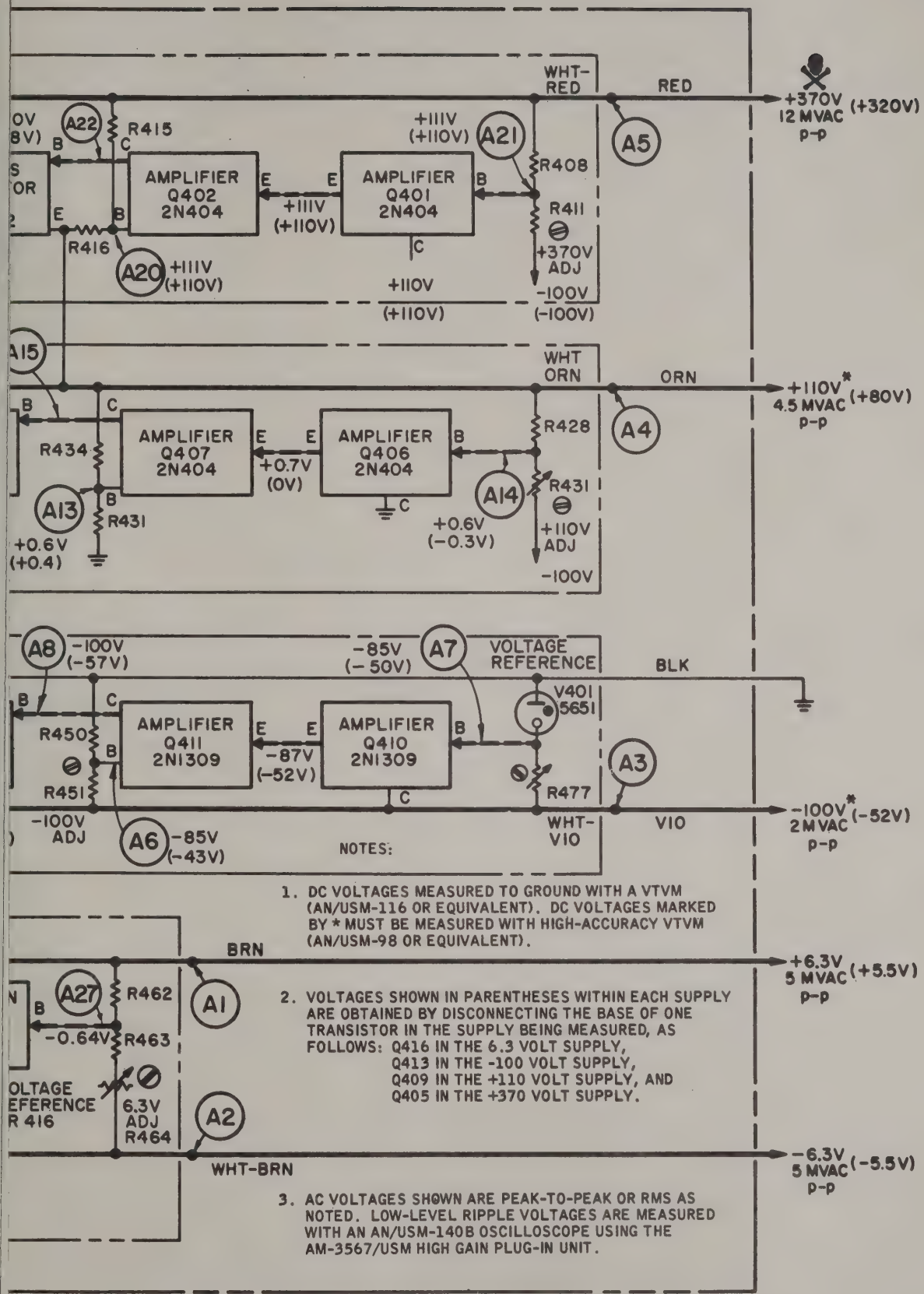


Figure 4-3. Low-Voltage Power Supply Functional and Servicing Block Diagram

TABLE 4-3. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
		+370 VOLT SUPPLY	
32	Check fuse F403 and replace if faulty.	Voltage at A5 returns to normal	1
		Replacement fuse blows	33
		Fuse not faulty	35
33	Turn instrument off. Disconnect white/red lead from test point A5. Measure resistance to ground from test point A5 and from white/red lead.	If resistance at A5 is less than about 17K ohms, check load on +370 volt supply for shorts.	
		If resistance at white/red lead is less than about 13K ohms, check for short within the +370 volt supply.	
		Both resistances normal	34
34	Connect dummy loads to +370 volt, -100 volt, and +110 volt supplies as follows: connect resistance of 1160 ohms (150 watts) between ground and white/red lead removed from test point A5. Disconnect white/violet lead from test point A3, and connect resistance of 165 ohms (75 watts) between ground and white/violet lead. Disconnect white/orange lead from test point A4, and connect resistance of 125 ohms (150 watts) between ground and white/orange lead.	If voltage at A5 returns to +370 volts, check load for shorts.	
		If F403 blows again, check for short in +370 volt supply.	
35	Pull off base lead of Q405 and measure DC voltage at test point A5.	If voltage is correct (about +320 volts), check Q401 or Q402.	
		Voltage incorrect	36
36	With Q405 base lead still off, measure DC voltage at test point A25.	If voltage is correct (about -15 volts), check diodes CR401 through CR404, or +370 volt supply load.	
		If voltage is incorrect, check Q403, Q404, and Q405.	
37	Measure AC voltage between test points A25 and A5 with differential oscilloscope (AN/USM-140B with AM-3567/USM Plug-In).	Peak-to-peak voltage is less than about 11 volts	38
		If ripple is greater than about 11 volts, and frequency is 60 cps, check diodes CR401 through CR404.	
		If ripple is high and 120 cps, check C401, C403, CR401 through CR404, or load on +370 volt supply.	
38	Measure AC voltage between test points A20 and A22.	Peak-to-peak voltage is at least 0.8 times that measured in step 3 (typically 10 mv)	39
		If AC voltage is much less than 0.8 times that measured in step 3, check Q401 and Q402.	
39	Measure AC voltage between test points A22 and A25.	If AC voltage is much less than 1000 times that measured in step 38 (typically 11 volts), check Q403, Q404, and Q405.	

Typical Peak-to-Peak Ripple Voltage Levels

TEST POINT	VOLTS
A4-A5	6 mv
A20-A22	10 mv
A22-A25	11 V
A5-A25	11 V
A26	675 V
A4-Gnd	4.5 mv
A13-A16	20 mv
A16-A18	10 V
A4-A18	11 V
A19	475 V
A3-Gnd	2 mv
A6-A9	3 mv
A9-A11	8 V
A12	425 V
A1-A2	2.5 mv
A27-A28	75. mv
A28-A30	1.2 V
A1-A30	1.2 V
A31	130 V

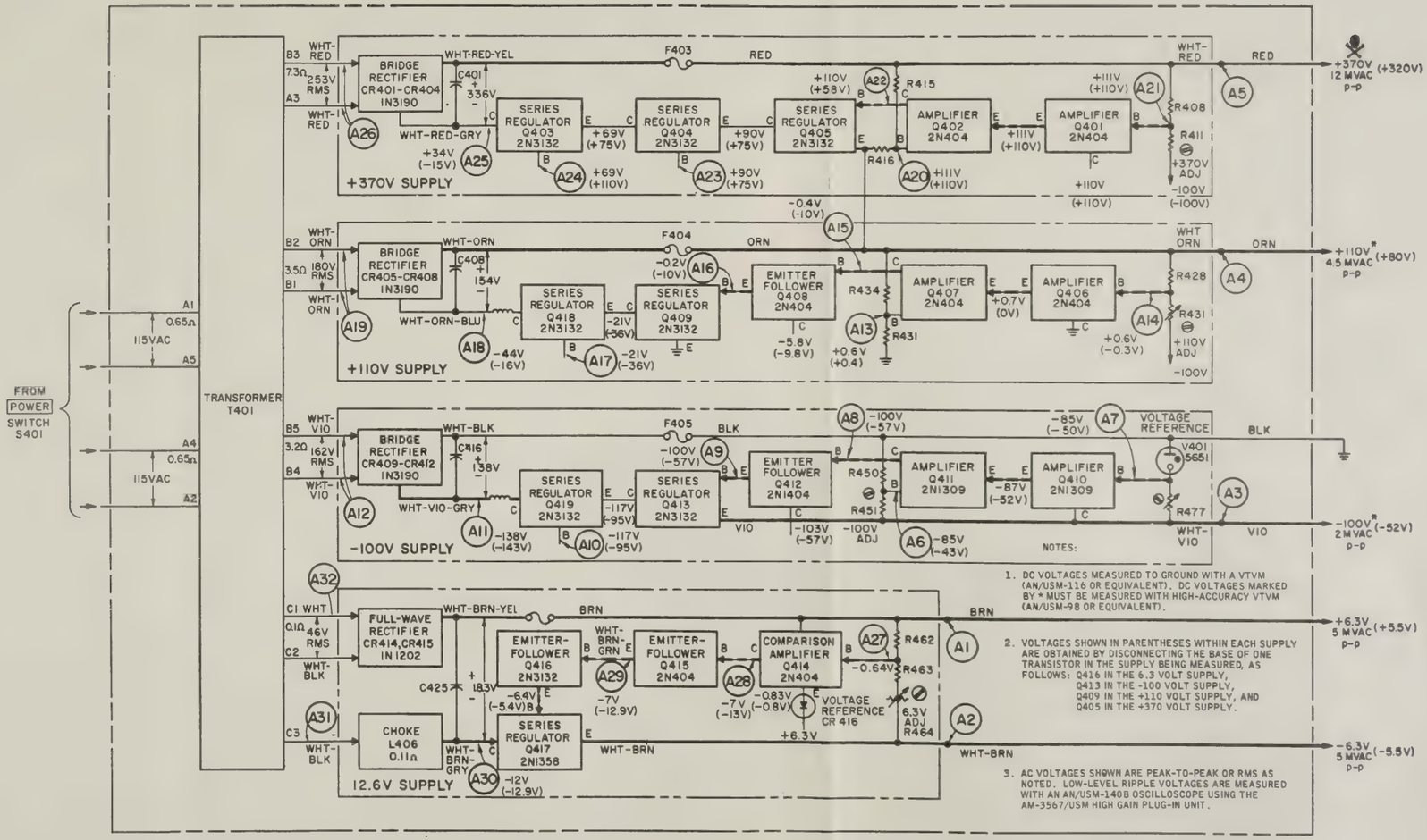

FROM POWER SWITCH S401
TRANSFORMER T401
+370V SUPPLY
+110V SUPPLY
-100V SUPPLY
12.6V SUPPLY
BRIDGE RECTIFIER CR401-CR404 1N3190
SERIES REGULATOR Q403 2N3132
SERIES REGULATOR Q404 2N3132
SERIES REGULATOR Q405 2N3132
AMPLIFIER Q402 2N404
AMPLIFIER Q401 2N404
BRIDGE RECTIFIER CR405-CR408 1N3190
SERIES REGULATOR Q418 2N3132
SERIES REGULATOR Q409 2N3132
EMITTER FOLLOWER Q408 2N404
AMPLIFIER Q407 2N404
AMPLIFIER Q406 2N404
BRIDGE RECTIFIER CR409-CR412 1N3190
SERIES REGULATOR Q419 2N3132
SERIES REGULATOR Q413 2N3132
EMITTER FOLLOWER Q412 2N1404
AMPLIFIER Q411 2N1309
AMPLIFIER Q410 2N1309
VOLTAGE REFERENCE
FULL-WAVE RECTIFIER CR414,CR415 1N1202
CHOKE L406 0.11Ω
EMITTER-FOLLOWER Q416 2N3132
EMITTER-FOLLOWER Q415 2N404
COMPARISON AMPLIFIER Q414 2N404
SERIES REGULATOR Q417 2N1358
VOLTAGE REFERENCE CR 416
+370V ADJ
+110V ADJ
-100V ADJ
6.3V ADJ
+370V 12 MVAC p-p (+320V)
+110V* 4.5 MVAC p-p (+80V)
-100V* 2 MVAC p-p (-52V)
+6.3V 5 MVAC p-p (+5.5V)
-6.3V 5 MVAC p-p (-5.5V)
NOTES:
1. DC VOLTAGES MEASURED TO GROUND WITH A VTVM (AN/USM-116 OR EQUIVALENT). DC VOLTAGES MARKED BY * MUST BE MEASURED WITH HIGH-ACCURACY VTVM (AN/USM-98 OR EQUIVALENT).
2. VOLTAGES SHOWN IN PARENTHESES WITHIN EACH SUPPLY ARE OBTAINED BY DISCONNECTING THE BASE OF ONE TRANSISTOR IN THE SUPPLY BEING MEASURED, AS FOLLOWS: Q416 IN THE 6.3 VOLT SUPPLY, Q413 IN THE -100 VOLT SUPPLY, Q409 IN THE +110 VOLT SUPPLY, AND Q405 IN THE +370 VOLT SUPPLY.
3. AC VOLTAGES SHOWN ARE PEAK-TO-PEAK OR RMS AS NOTED. LOW-LEVEL RIPPLE VOLTAGES ARE MEASURED WITH AN AN/USM-140B OSCILLOSCOPE USING THE AM-3567/USM HIGH GAIN PLUG-IN UNIT.

Figure 4-3. Low-Voltage Power Supply Functional and Servicing Block Diagram

4-5. HIGH-VOLTAGE POWER SUPPLY.

a. HIGH-VOLTAGE POWER SUPPLY FUNCTIONAL DESCRIPTION. The high-voltage power supply consists of a single 50-kilocycle oscillator supplying power to three different sets of rectifiers: (1) +8500 volts for the CRT post accelerator; (2) -1500 volts for the CRT cathode; and (3) an additional -1600 volts for the CRT control grid. The reason for the additional -1600 volt supply is to permit this supply to be varied for intensity control and intensity modulation without affecting the voltage applied to the cathode. The High-Voltage Power Supply Functional and Servicing Block Diagram, figure 4-4, shows the functional relationship of all circuits in the high-voltage power supply, and gives test points and voltages as an aid in trouble shooting.

The amplitude of the 50-kc oscillator is regulated by feedback taken from the -1500 volt CRT cathode voltage. A sample of the -1500 volts is fed through a voltage divider and the H. V. ADJ potentiometer (R321) to the grid of the regulator amplifier, whose cathode is grounded. Any shift in the -1500 volts is amplified in both V301A and B and applied to the screen grid of the oscillator tube V304. If the -1500 volt output tends to decrease (vary in a positive direction), the voltage applied to the oscillator grid also goes positive and increases the oscillation amplitude. If the -1500 volts should tend to increase, the oscillation amplitude would be decreased by the applied screen voltage, and thus the -1500 volts is held constant in either case. A shift in the +8500 and -1600 volt supplies is not sensed by the regulator amplifier unless that shift also causes a shift in the -1500 volt supply. The +8500 volts is obtained by voltage doubling in V308 and V309. During the negative half cycle at terminal 1 on T301, V309 conducts and charges C305 to about 4300 volts. During the positive half cycle V308 conducts with the +4300 volts charge in series with (adding to) the transformer voltage. C306 and C315 bypass the 50-kc ripple.

The high-voltage oscillator is located on etched circuit A301 mounted under a cover on the upper left side of the oscilloscope chassis as shown in figure 5-9. When the cover is removed, voltages in excess of 8500 volts are exposed.

b. HIGH-VOLTAGE POWER SUPPLY TROUBLE SHOOTING. Malfunctions in the high-voltage power supply fall into three classes: (1) no voltage, or incorrect voltage that cannot be adjusted, (2) output voltage which does not remain constant when the intensity control is adjusted over its full range, and (3) excessive noise in the output voltage. The first step in trouble shooting the high-voltage supply is to classify the trouble symptom by observation of the CRT trace. No voltage, or high or low voltage are usually identified by such symptoms as no spot when the beam finder is pressed, a poorly focused spot, a spot that cannot be turned off, a high or low horizontal and vertical deflection sensitivity. The step-by-step trouble-shooting procedure is given in table 4-4. Trouble-shooting techniques are further discussed below.

Poor regulation of the high voltages is usually identified as such by a change in horizontal and vertical sensitivity as the intensity control is varied over its full range.

Noise in the high-voltage power supply usually appears as undesired intensity modulation of the spot. The usual cause is corona discharge, arcing, or breakdown of capacitors and other dielectrics in the +8500-volt supply components. To locate the source of such a malfunction, first look for signs of arcing while the oscilloscope is operating; darkening the room may help. If no signs of arcing appear, measure the DC voltage at the test points and note any signs of jumpiness. Look for the test point where jumpiness is greatest. If the source of the breakdown still cannot be located, make resistance checks of suspect components or substitute new parts for C305, C306, C315, associated wires, R311, etc.

WARNING

Use great care in making voltage measurements when trouble shooting the high-voltage supply. The high-voltage power supply produces lethal voltages as high as +8500V. Read and understand each step before beginning. Work with one hand only and do not touch exposed wires or terminals with power applied.

USEFUL ILLUSTRATIONS OF THE HIGH-VOLTAGE POWER SUPPLY

Illustration	Figure No.	Page No.
Block Diagram	4-4	4-19, 4-20
Location of Test Points	4-15	4-48
Location of Parts	5-26 5-27	5-43 5-45
Schematic Diagram	5-43	5-71, 5-72

4-6. BEAM FINDER CIRCUIT.

a. BEAM FINDER CIRCUIT FUNCTIONAL DESCRIPTION. The BEAM FINDER pushbutton switch reduces both the horizontal and veritcal amplifier gains and momentarily brightens the CRT display. As a result, any elusive trace is brought to an on-screen position on the CRT and can be located with the regular positioning controls to remain in the center when the BEAM FINDER switch is released.

A simplified schematic of the beam finder circuit is shown in figure 4-5. The connection of the beam finder circuit to the main vertical amplifier is also shown in the functional block diagram of figure 4-8. To reduce the horizontal gain, the switch adds R268 in series with the cathode supply for V204/V205, greatly reducing the current supplied to this stage. Thus, with the BEAM FINDER pushed, the stage gain is low enough to restrict the deflection to within the exposed face of the CRT.

To reduce the vertical gain, the switch adds R88 in series with the cathode supply for V11A/V12B and V11B/V13B. The vertical gain is further reduced by lowering the common cathode voltage for V12A and V13A. A stabilizing resistor, R99, is used

TABLE 4-4. HIGH-VOLTAGE POWER SUPPLY TROUBLE SHOOTING

STEP	ACTION	RESULTS	NEXT STEP
1	Measure DC voltage at supply outputs (test points B1, B2, and B3).	If voltages are correct, check CRT.	
		One or more voltages are incorrect	2
2	Remove CRT socket.	If voltages return to normal, replace CRT.	
		Voltages still incorrect	3
3	Measure DC voltage at test points B1, B2, and B3.	Voltage at B1 incorrect	14
		Voltage at B2 incorrect	13
		Voltage at B3 incorrect	15
		All voltages low	4
		If all voltages high, check V301.	
4	Observe waveform at test point B9.	If indication is normal (50-kc sine wave, indicated on schematic), check rectifiers and load on all three supplies.	
		Waveform incorrect, intermittent, or not present	5
5	Remove rectifiers V308 through V311, and observe waveform at test point B9.	Indication returns to normal	6
		Waveform still incorrect (Replace rectifiers for next step.)	7
6	Replace rectifiers one at a time and re-check waveform at test point B9.	Note which supply stops or causes incorrect oscillation. Check components including transformer T301 for that supply.	
7	Remove V301 and measure DC voltage at test point B8.	Voltage about -47 volts (voltage shown on schematic in parentheses)	11
		Voltage incorrect or intermittent	8
8	Measure DC voltage at test point B9.	Voltage about +366 volts	9
		Voltage incorrect	10
9	Measure DC voltage at test point B7.	If voltage is correct (+180 volts), check V304, T301, or C304.	
		If voltage is incorrect, check R302 and C303.	
10	Measure DC voltage at test point B10.	If voltage is correct (+370 volts), check V304, T301, or C304.	
		If voltage is incorrect, check L301 or +370 volt supply.	
11	Measure DC voltage at test point B5.	Voltage about -43 volts	12
		Voltage incorrect	13
12	Re-install V301 and measure DC voltage at test point B7.	Voltage about +170 volts	13
		If voltage is incorrect, check V301.	
13	Remove V301 and measure DC voltage at test point B2.	Voltage about -1940 volts	14
		Voltage incorrect	16

TABLE 4-4. (Continued)

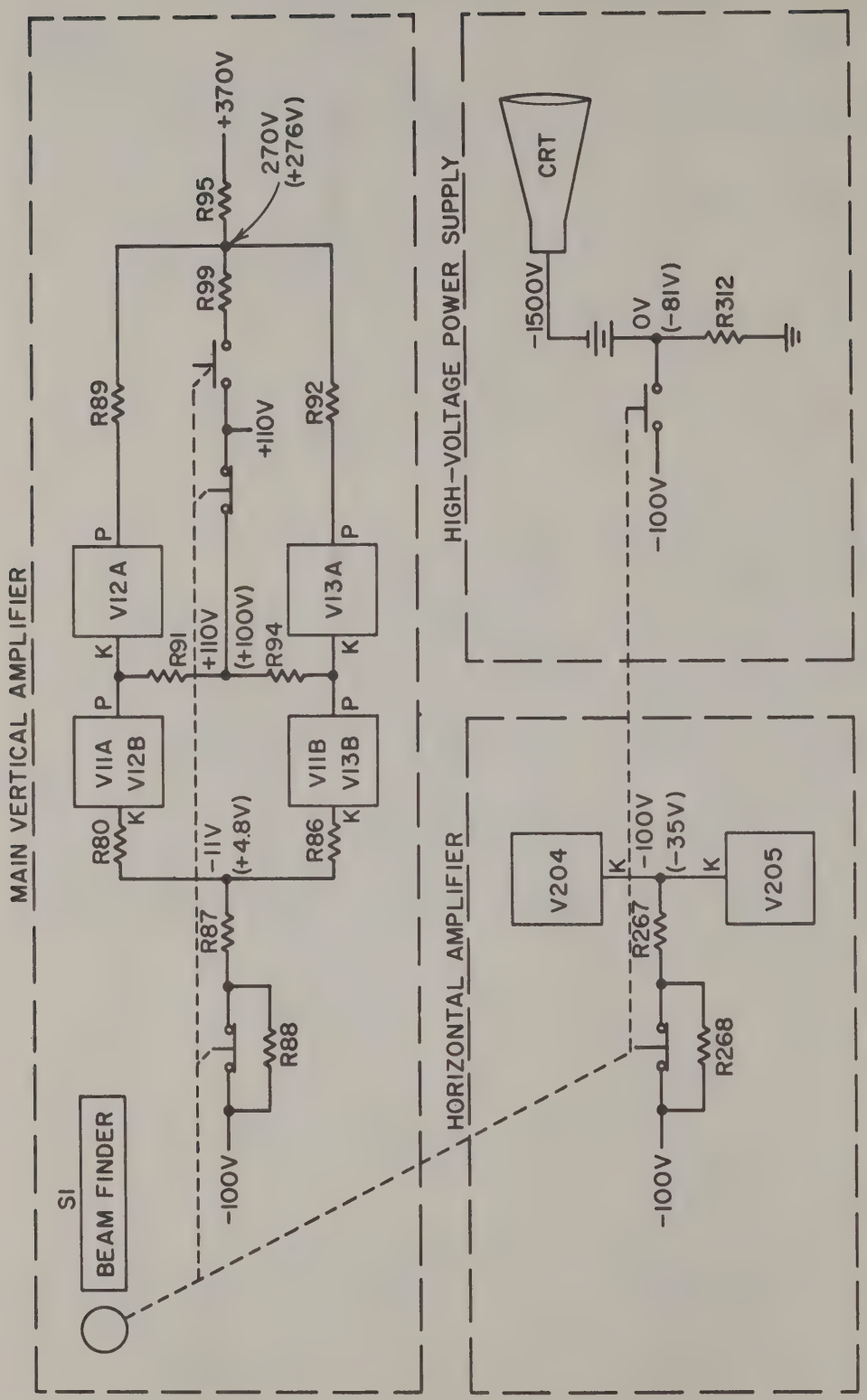
STEP	ACTION	RESULTS	NEXT STEP
14	Measure DC voltage at test point B1.	Voltage about -1760 volts	15
		If voltage is incorrect, check V310, C307, and C311.	
15	Measure DC voltage at test point B3.	If voltage is correct (10,100 volts), check CRT and voltages at CRT elements.	
		If voltage is incorrect, check V308 and V309.	
16	Measure DC voltage at test point B1.	If voltage is correct (-1760 volts), check V311 and C308.	
		If voltage is incorrect, check T301.	

to keep the plate potential constant for these two tubes. As a result of these conditions, the vertical gain is low enough with the BEAM FINDER switch pressed that the beam cannot be deflected off the CRT face.

In the high-voltage supply, the -1500 volt cathode supply for the CRT is returned to -100 volts instead of to ground when the BEAM FINDER is pressed. This additional negative voltage at the CRT cathode causes the grid to become relatively more positive, and thereby overrides any cut-off bias voltage which may exist between the CRT grid and cathode, producing a brightened, defocused beam.

b. BEAM FINDER CIRCUIT TROUBLE SHOOTING. Trouble shooting the beam finder circuit assumes that the high-voltage supply, the main vertical amplifier, and the horizontal amplifier are known to be operating satisfactorily. Trouble symptoms in the beam finder circuit fall into four classes: (1) spot cannot be centered horizontally, (2) spot cannot be centered vertically, (3) spot does not brighten, or (4) no spot.

The first step in trouble shooting the beam circuit is to measure the voltage differences given in figure 4-5. These will indicate the general location of the trouble. From the class of trouble and its general location, a logical choice can be made as to the faulty components. Tubes within the suspected circuit should be checked by comparison, and the required adjustments should be made if any tubes are replaced. If the tubes are operating correctly, check the BEAM FINDER switch, S1. With all power removed from the oscilloscope, use an ohmmeter to check continuity of the opened and closed circuits in the four-pole switch. If the switch, its wiring, and all connections are satisfactory, check the passive elements in the suspected circuit.



NOTE:

1. DC VOLTAGES MEASURED TO GROUND WITH A VTVM (AN/USM-116 OR EQUIVALENT).
2. VOLTAGES WITHOUT PARENTHESES ARE NORMAL VOLTAGES; VOLTAGES IN PARENTHESES ARE MEASURED WHILE BEAM FINDER SWITCH IS PRESSED.

Figure 4-5. Simplified Schematic Diagram of the Beam Finder Circuit

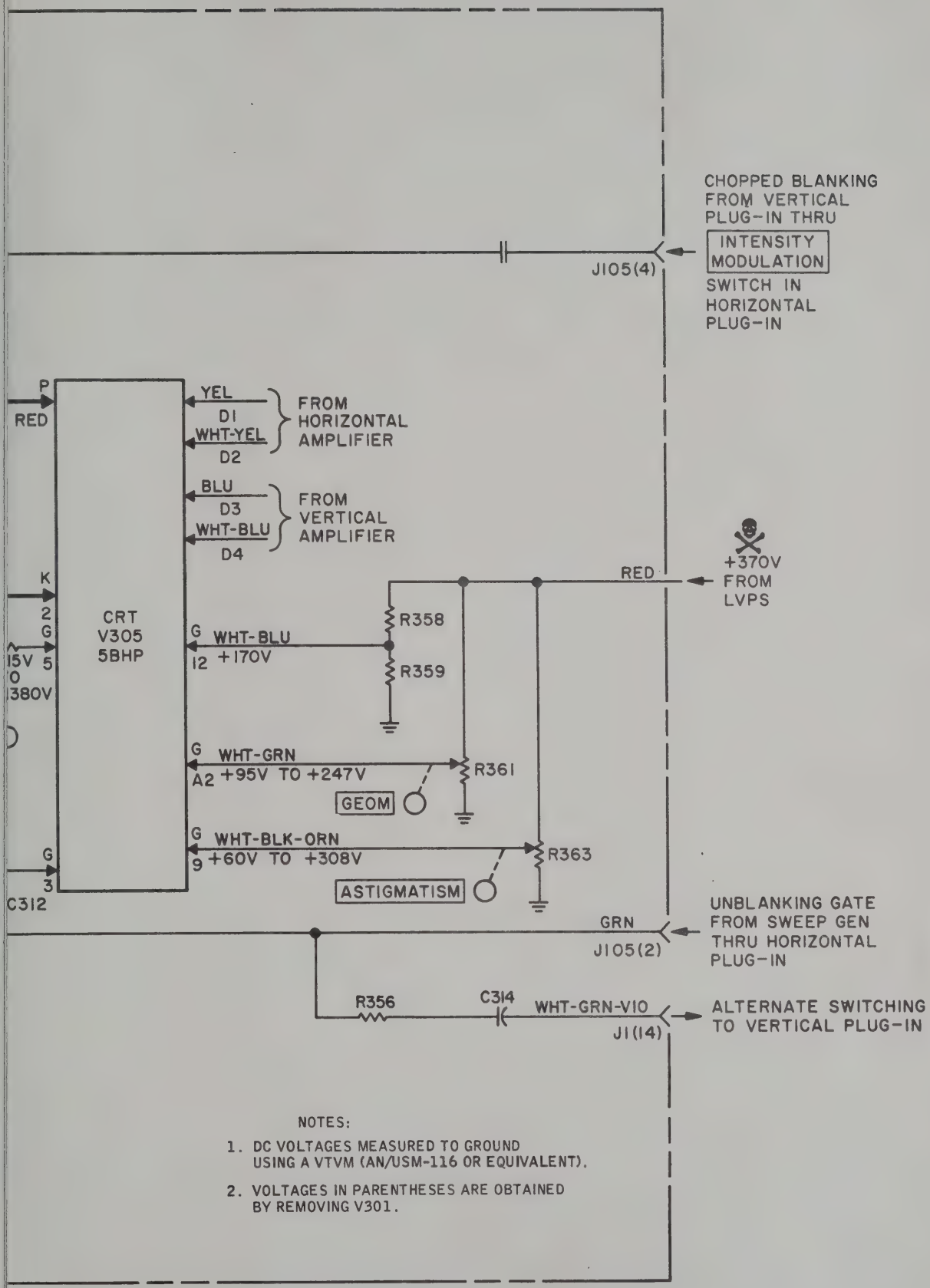
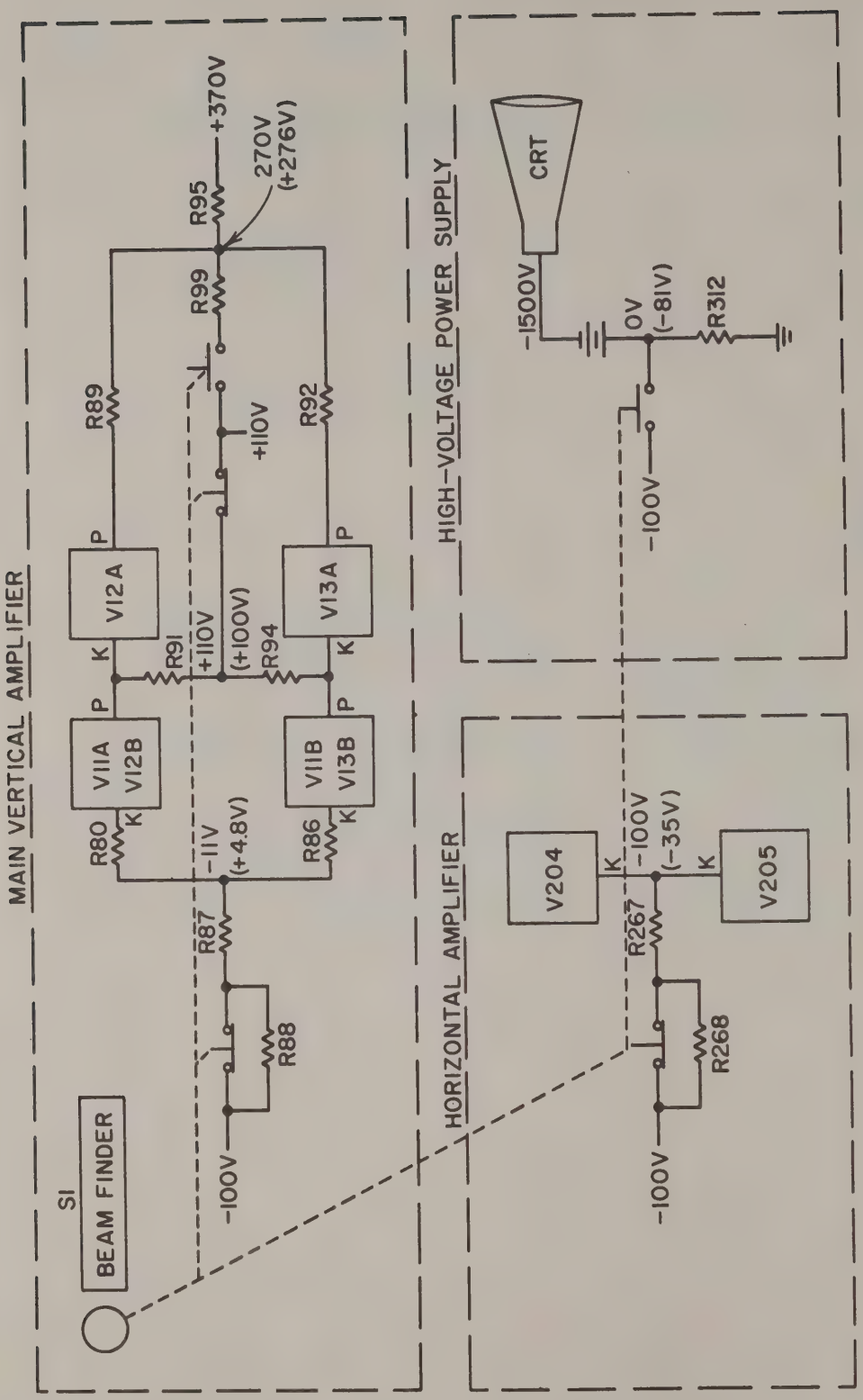


Figure 4-4. High-Voltage Power Supply Functional and Servicing Block Diagram



NOTE:

1. DC VOLTAGES MEASURED TO GROUND WITH A VTVM (AN/USM-116 OR EQUIVALENT).
2. VOLTAGES WITHOUT PARENTHESES ARE NORMAL VOLTAGES; VOLTAGES IN PARENTHESES ARE MEASURED WHILE BEAM FINDER SWITCH IS PRESSED.

Figure 4-5. Simplified Schematic Diagram of the Beam Finder Circuit

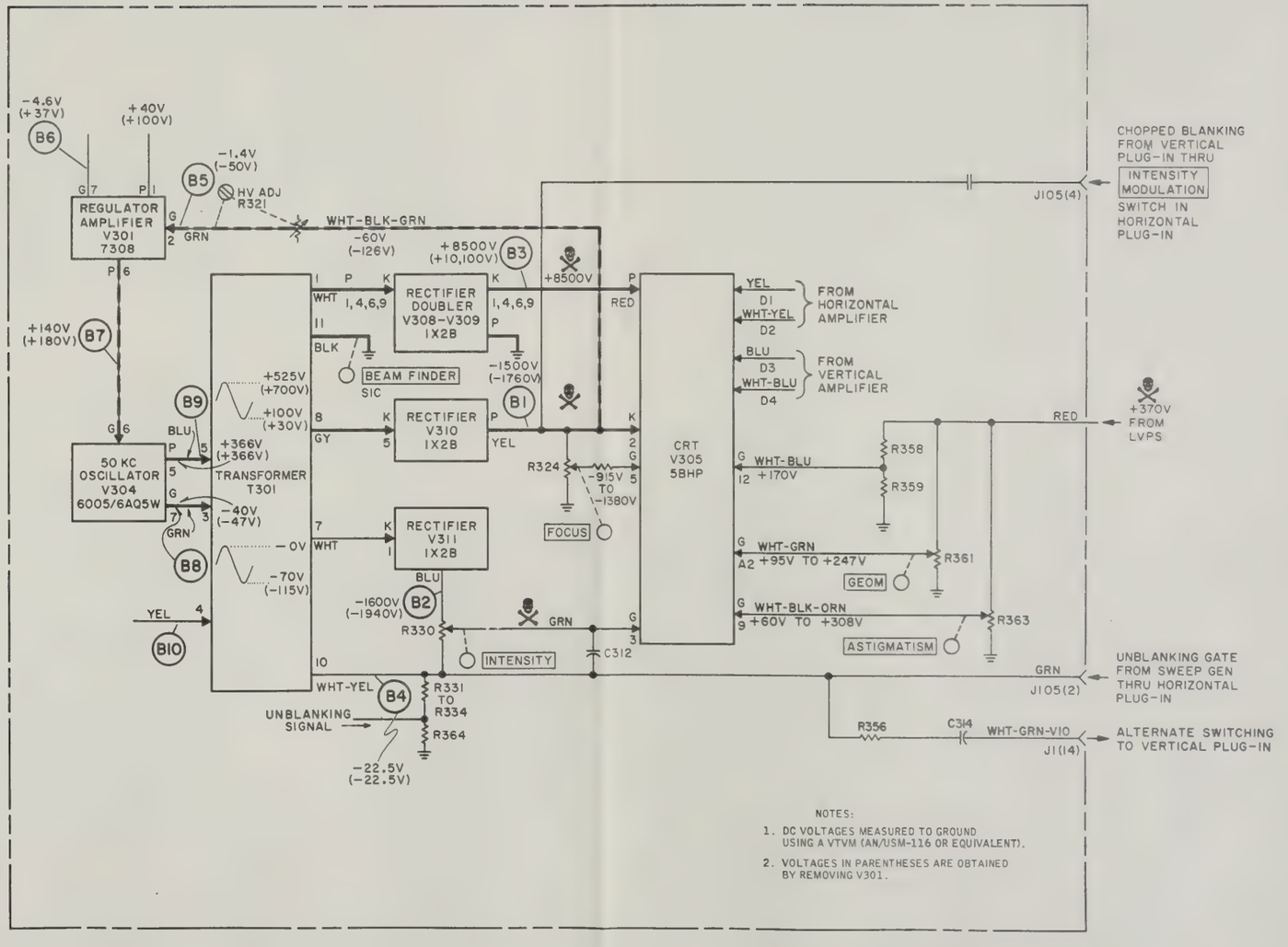


Figure 4-4. High-Voltage Power Supply Functional and Servicing Block Diagram

4-7. MAIN VERTICAL AMPLIFIER.

a. MAIN VERTICAL AMPLIFIER FUNCTIONAL DESCRIPTION. The main vertical amplifier receives a balanced input signal from the MX-2930B/USM Vertical Plug-In Amplifier, amplifies this signal, and drives the CRT deflection plates. The main vertical amplifier consists of two etched circuit assemblies A1 and A2 located on each side of the upper oscilloscope chassis (see figure 5-9). The signal from the input circuit A1 is coupled to the output amplifier A2 through a pair of 0.2 microsecond delay lines DL1 and DL2 located around the fan housing, as shown in figure 5-4. The Main Vertical Amplifier Functional and Servicing Block Diagram is shown in figure 4-8.

Input etched circuit A1 includes a balanced input Cathode Follower V1 followed by a balanced Cascode Amplifier V2 and V3, and a separate four-stage, single-ended amplifier that supplies the internal sync signal to the sweep generator for use in generating an internal sweep trigger. By taking the sync signal from the vertical amplifier ahead of the delay lines, it is possible to start the sweep before the vertical signal that initiated the sync is presented to the CRT. Thus, the vertical signal is automatically synchronized with a horizontal time-variable sweep.

The cascode amplifier is a two-stage amplifier with a conventional grid-coupled input and a grounded-grid output. It is used to obtain the high gain of a pentode and the low noise of a triode. Figure 4-6 shows a simplified schematic of the V2/V3 balanced cascode amplifier circuit. A positive input signal from the input cathode follower is fed to the control grid of V2B. The signal is amplified and the phase is shifted 180°. There is no additional phase shift in the grounded-grid section. The Gain Adj resistor, R13, in the cathode circuit adjusts the gain of the cascode amplifier and sets the overall gain of the main vertical amplifier.

Output amplifier A2 includes an input Cathode Follower V6, a Cascode Amplifier A11, A12, and A13 supplemented by a Constant Current Generator to permit DC coupling between the input and output stages. The Cross-Coupled Cathode Follower (shown in simplified form in figure 4-6) consists of tube V6A and B which provides a high input impedance load to the delay line and a low output impedance to drive the following cascode amplifier. To compensate for the tendency of the load to increase with frequency, the cathode followers are cross-coupled. Cross-coupling places the plate impedance of the opposite side in parallel with the cathode impedance of the first side, thus decreasing it. The cross-coupling capacitors C23 and C24 add this parallel impedance at the high frequencies only.

Constant Current Generator V7 provides a constant direct current through coupling resistors R52 and R68, thus producing a constant DC drop of about 150 volts across each resistor and allowing the following cascode amplifier grids to be operated at near 0 volts. A simplified schematic of this circuit is shown in figure 4-7. There is no significant loss in signal across the voltage-dropping network. R50 and R67 apply a small signal to each grid of V7, thereby maintaining a constant current through the tube as the plate voltage changes through the signal cycle. Capacitors C22 and C25 prevent DC shorting of the voltage drop; inductors L19 and L20 provide series resonance with the input capacity of V11A/B, V12B, and V13B to increase high frequency gain. Resistors R53 and R69 isolate the output capacity of V7 from the grids of V10, V11, V12, and V13. V8 and V9 are safety devices that prevent the voltage applied to the following grids from rising excessively in the event V7 fails or is removed from the socket during operation.

The final Cascode Amplifier uses parallel input triodes to double the gain without increasing the plate capacity in the output. The additional current required by the two parallel triodes is drawn through R91 and R94.

The cathode follower stages of V10A and V10B are used only when a special scanner plug-in unit is installed in place of the MX-3078/USM Auxiliary Plug-In Unit. At other times this stage has no effect on the main vertical amplifier circuit operation.

In the servicing block diagram (figure 4-8) and the schematic diagram for the main vertical amplifier (figure 5-37), the DC voltages shown at the test points are measured with the balanced amplifier stages in exact balance. In practice, various degrees of unbalance are normal. When the vertical position control is adjusted to balance the voltages of a particular stage, the voltages should be within about 10% of those shown and the CRT trace will normally be within 1 centimeter of center. Stage gain measurements are usually made at frequencies between 400 cycles and 20 kilocycles to avoid the loading effect of the test prod. Gain can also be measured at DC, using a DC voltmeter and by adjusting the vertical position control to provide the signal. The DC gain is equal to the AC gain.

b. MAIN VERTICAL AMPLIFIER TROUBLE SHOOTING. Trouble symptoms in the main vertical amplifier fall into four classes: (1) the spot cannot be centered vertically (DC unbalance); (2) high noise level (ripple or microphonics); (3) incorrect midband sensitivity; or (4) poor high-frequency (pulse) response. Three separate procedures are given for trouble shooting these problems in the trouble-shooting chart, table 4-5. The procedure given for trouble shooting for DC unbalance should also be used in trouble shooting for excessive noise level. Before trouble shooting a problem of sensitivity, be sure that the DC balance and the CRT deflection sensitivity are satisfactory (CRT deflection sensitivity can be checked in response to horizontal deflection, indicating that proper high-voltage power supply voltages are applied to the CRT). Since proper pulse (high frequency) response depends upon suitable balance and midband sensitivity, the procedure for trouble shooting high frequency response is presented last in table 4-5, and presumes that the balance and midband sensitivity are properly set. The trouble-shooting techniques upon which the step-by-step procedures of table 4-5 are based are discussed below.

The quickest way to isolate the source of noise or DC unbalance is to connect a jumper across corresponding circuit points on the top and bottom sides of the vertical amplifier. If this eliminates the noise or unbalance the trouble is ahead of the short; if the trouble persists, the source is after the short. The

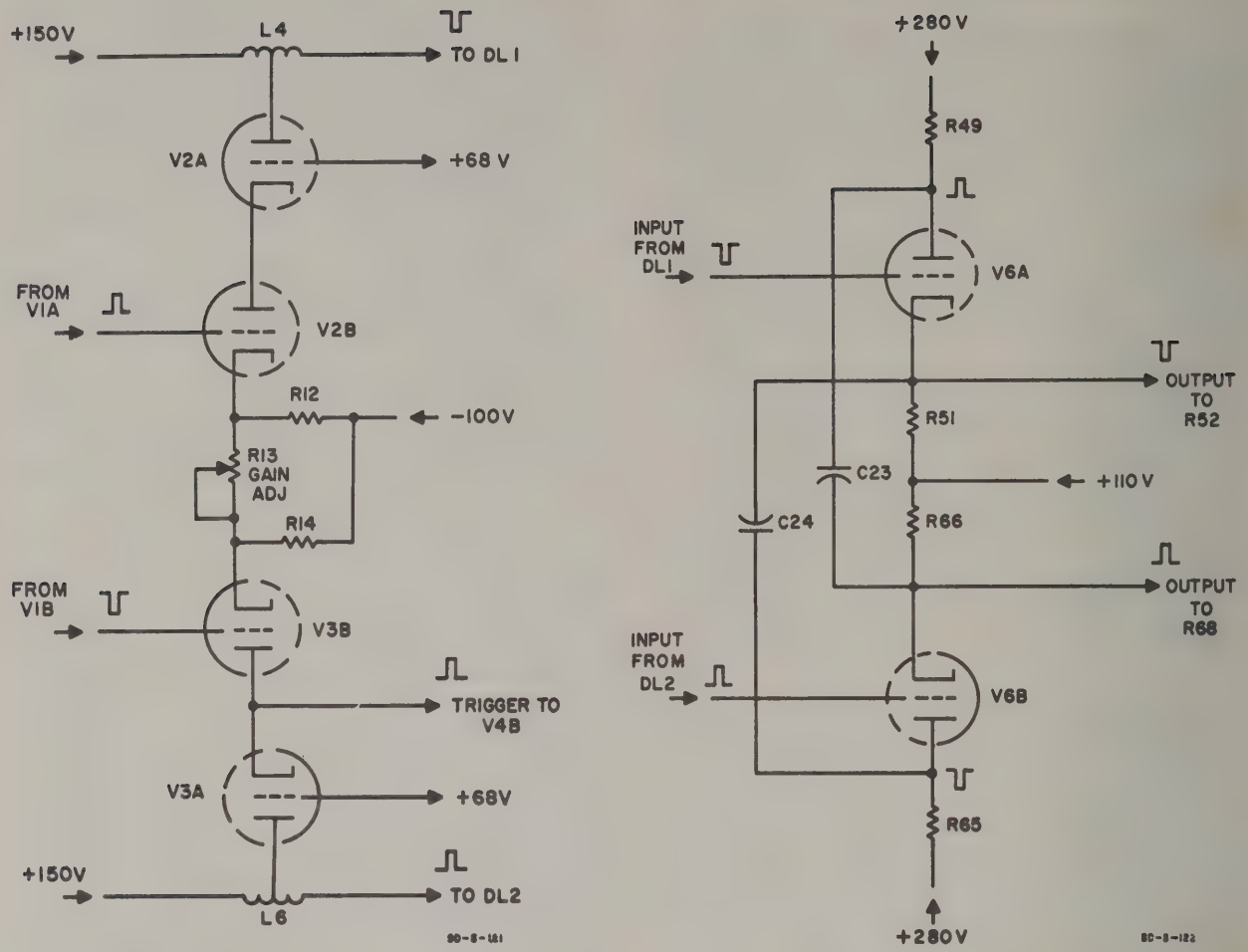


Figure 4-6. Cascode Amplifier/Simplified Schematic Diagram and Cross-Coupled Cathode Follower

noise level in the output, across test points E15 and E16, should not exceed 0.2 volt peak-to-peak. Sharp taps on the rear of the chassis should not produce a spot deflection of more than 5 millimeters.

The trouble-shooting procedure of table 4-5 utilizes this method of a "half-split" sequence, i.e., making the first test midway in the amplifier, the second test midway in the amplifier half found defective by the first test, and so on. After the trouble is isolated to a stage, the faulty part can be located by making DC voltage measurements and comparing them to the voltages given on the servicing block diagram and the schematic diagram.

Insufficient sensitivity (low gain) in the amplifier is usually caused by a weak tube, incorrect heater, or defective plate supply voltage. The method used to isolate the source of low sensitivity is to apply a 400-cycle sine-wave signal directly to the vertical amplifier and then to make the AC measurements as shown on the servicing block diagram, figure 4-8. Again the "half-split" method is used, beginning at the center of the amplifier to determine which half is defective, going to the center of the defective half for the second test, and so on. The AC measurements are made across the two sides of the amplifier to simplify the readings. The measuring instrument used must not shift the vertical position of the trace when it is connected to the circuit. After the stage causing low sensitivity is repaired, adjust the Vert Gain control, R13, to obtain 2.5-centimeters vertical deflection with an 0.5-volt peak-to-peak input.

Before trouble shooting a problem of high frequency response, be sure that the DC balance and midband sensitivity are satisfactory. The test for correct pulse response is to apply a 1-mc square wave of near-perfect shape to the oscilloscope input. If any undershoot or overshoot is observed on the CRT, the most likely cause is a defective tube, lack of proper adjustment following replacement of a tube, or physical damage to the delay lines, their terminations, or any of the series-peaking coils on the vertical amplifier etched circuit assemblies.

USEFUL ILLUSTRATIONS OF THE MAIN VERTICAL AMPLIFIER

Illustration	Figure No.	Page No.
Block Diagram	4-8	4-27, 4-28
Location of Test Points	4-19	4-52
Location of Parts	5-14 5-15	5-31
Schematic Diagram	5-37	5-59, 5-60

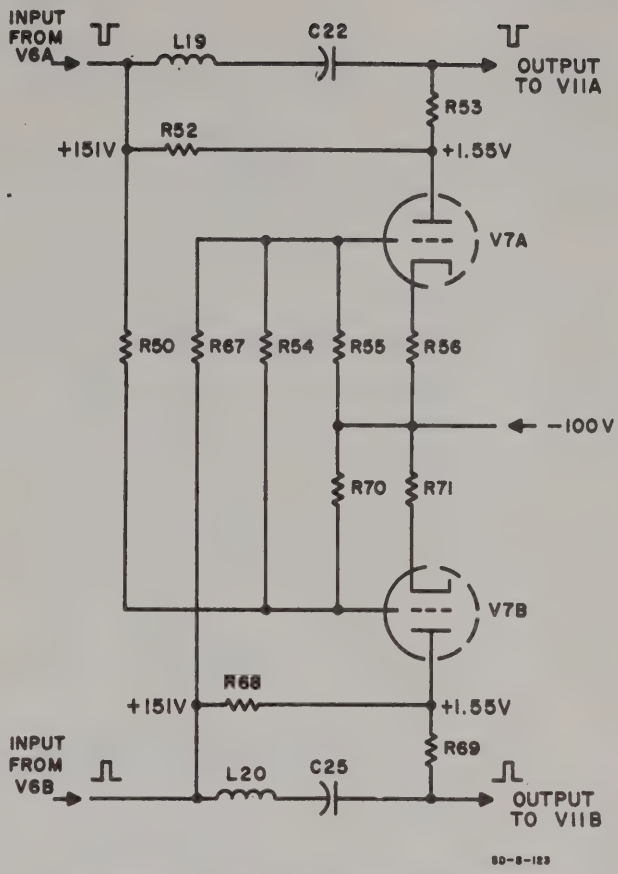


Figure 4-7. Constant Current Generator Simplified Schematic Diagram

TABLE 4-5. MAIN VERTICAL AMPLIFIER TROUBLE SHOOTING

STEP	ACTION	RESULTS	NEXT STEP
	DC UNBALANCE		
1	Remove Dual Channel Vertical Plug-In. Set up controls to get spot or trace on screen.	Trace or spot is within ±2 cm of center	2
		Trace or spot greater than ±2 cm from center	3
2	Insert MX-2930B/USM Dual Channel Vertical Plug-In. Allow to warm up. Set to CHANNEL A and center spot with VERTICAL POSITION control. Repeat for CHANNEL B.	Trace can be centered in both CHANNEL A and CHANNEL B, with positioning controls near center of range. Main vertical and dual channel plug-in operating normally.	
		If trace can't be centered by one or the other or both positioning controls, with control approximately in center of range, refer to Dual Channel Plug-In Trouble Shooting procedure.	
3	Connect jumper between test points E5 and E6.	Trace centers	4
		Trace doesn't center	5

TABLE 4-5. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
4	Connect jumper between test points E3 and E4.	If trace centers, check DC voltages around V1A and V1B.	
		If trace doesn't center, check DC voltages around V2 and V3.	
5	Connect jumper between test points E11 and E12.	Trace centers	6
		Trace doesn't center	8
6	Connect jumper between test points E9 and E10.	Trace centers	7
		If trace doesn't center, check DC voltages around V7A/B.	
7	Connect jumper between test points E7 and E8.	If trace centers, check delay line.	
		If trace doesn't center, check DC voltages around V6A/B.	
8	Connect jumper between test points E13 and E14.	If trace centers, check DC voltages around V11A/B, V12B, V13B.	
		Trace doesn't center	9
9	Connect jumper between test points E15 and E16.	If trace centers, check DC voltages around V12A and V13A.	
		If trace doesn't center, check CRT and connections to CRT.	
	SENSITIVITY		
10	Set up equipment as in table 5-7, step 10.	If peak-to-peak deflection is 4 cm ±0.2 cm, main vertical sensitivity is correctly set.	
		Peak-to-peak deflection is not 4 cm ±0.2 cm	11
11	Adjust Vert Gain R13 for peak-to-peak deflection of 4 cm ±0.2 cm.	If gain can be adjusted to correct sensitivity, main vertical amplifier is operating correctly.	
		R13 can't adjust deflection to 4 cm	12
12	Adjust R13 for maximum gain. Set CALIBRATOR signal to 0.5 volts peak-to-peak.	If vertical deflection is greater than 2.5 cm (peak-to-peak), main vertical amplifier is operating correctly. Repeat step 11.	
		Less than 2.5 cm deflection	13
13	Measure AC voltage between test points E5 and E6 with differential oscilloscope (AN/USM-140B with AM-3567/USM Plug-In).	AC voltage approximately 2.9 volts peak-to-peak	16
		AC voltage less than about 2.9 volts peak-to-peak	14
14	Measure AC voltage between test points E3 and E4.	If AC voltage is about 0.48 volt peak-to-peak, measure DC voltages around V2A/B and V3A/B, including heaters.	
		AC voltage low (less than about 0.48 volt peak-to-peak)	15

TABLE 4-5. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
15	Measure AC voltage between test points E1 and E2.	If AC voltage is about 0.5 volt peak-to-peak, measure DC voltages around V1A/B including heaters.	
		If AC voltage is low, check instrument set up.	
16	Measure AC voltage between test points E11 and E12.	AC voltage about 2.46 volts peak-to-peak	19
		AC voltage low (less than about 2.46 volts peak-to-peak)	17
17	Measure AC voltage between test points E9 and E10.	If AC voltage is about 2.54 volts peak-to-peak, check DC voltage around V7A/B, including heaters.	
		AC voltage low (less than about 2.54 volts peak-to-peak)	18
18	Measure AC voltage between test points E7 and E8.	If AC voltage is about 2.8 volts peak-to-peak, check DC voltages around V6A/B, including heaters.	
		If AC voltage is low (less than about 2.8 volts peak-to-peak), check delay line.	
19	Measure AC voltage between test points E13 and E14.	AC voltage about 0.84 volt peak-to-peak	20
		If AC voltage is low (less than about 0.84 volt peak-to-peak), check DC voltages around V11A/B, V12B, and V13B.	
20	Measure AC voltage between test points E15 and E16.	If AC voltage is about 19.2 volts peak-to-peak, check connections to CRT, high-voltage power supply, and CRT.	
		If AC voltage is low (less than about 19.2 volts peak-to-peak), check DC voltages around V12A and V13A, including heaters.	
	HIGH FREQUENCY RESPONSE		
21	Check main vertical amplifier rise time as in table 5-7, step 12.	If rise time (10-90%) is 11 nanoseconds or less, high frequency response is correct.	
		Rise time greater than 11 nanoseconds	22
22	Check DC unbalance by removing all connections from J1 (vertical plug-in connector).	Spot within ±2 cm of center of screen If spot is not within ±2 cm of center of screen, refer to DC unbalance trouble shooting procedure (step 1 of this procedure).	23
23	Check main vertical sensitivity as in table 5-7, step 10.	Peak-to-peak deflection is 4 cm ±0.2 cm	24
		If peak-to-peak deflection is not 4 cm ±0.2 cm, refer to sensitivity trouble shooting procedure (step 10 of this procedure).	

TABLE 4-5. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
24	Check main vertical amplifier passband as in table 5-7, step 11.	If 3-db point is higher than 30 mc, passband is correct.	
		3-db point is lower than 30 mc	25
25	Make a continuous check of frequency response from 50 kc to 35 mc.	If there are no dips or peaks in response, and 3-db point is higher than 30 mc, response is correct.	
		Dips or peaks present, or 3-db point is lower than 30 mc	26
26	Check DC voltages at test points E15 and E16 with spot centered.	Voltages are +180 volts ±10 volts	27
		If voltages are not +180 volts ±10 volts, make DC measurements throughout the amplifier until fault is located. Correct fault and repeat step 21.	
27	Set up equipment as in table 5-7. Adjust C31 (see Figure 5-3) and vertical deflection plate lead dress for flat top on pulse. Adjust C20, L1, and L2 for best corner on pulse.	If rise time (10-90%) is 11 nanoseconds or less, pulse response is correct.	
		If, with best setting of adjustments, rise time is greater than 11 nanoseconds: a. Check vertical deflection plate leads for poor connections. b. Replace tubes one at a time in the following order: V1, V6, V7, V12, V13, V11, V2, V3, V10, and V4. c. Short out inductor on opposite sides of the amplifier. If shorting on one side has same effect on pulse rise as opposite side, inductors are not faulty. If not, check and replace. Check pairs in the following order: L1 - L2 L3 - L5 L13 - L16 L14 - L17 L6 - L3 L4 - L6 L19 - L20 L21 - L22 d. Check C22 and C25 by paralleling with good one or replacing. e. If there are steps on the pulse top at multiples of 0.2 microseconds apart, replace delay lines.	

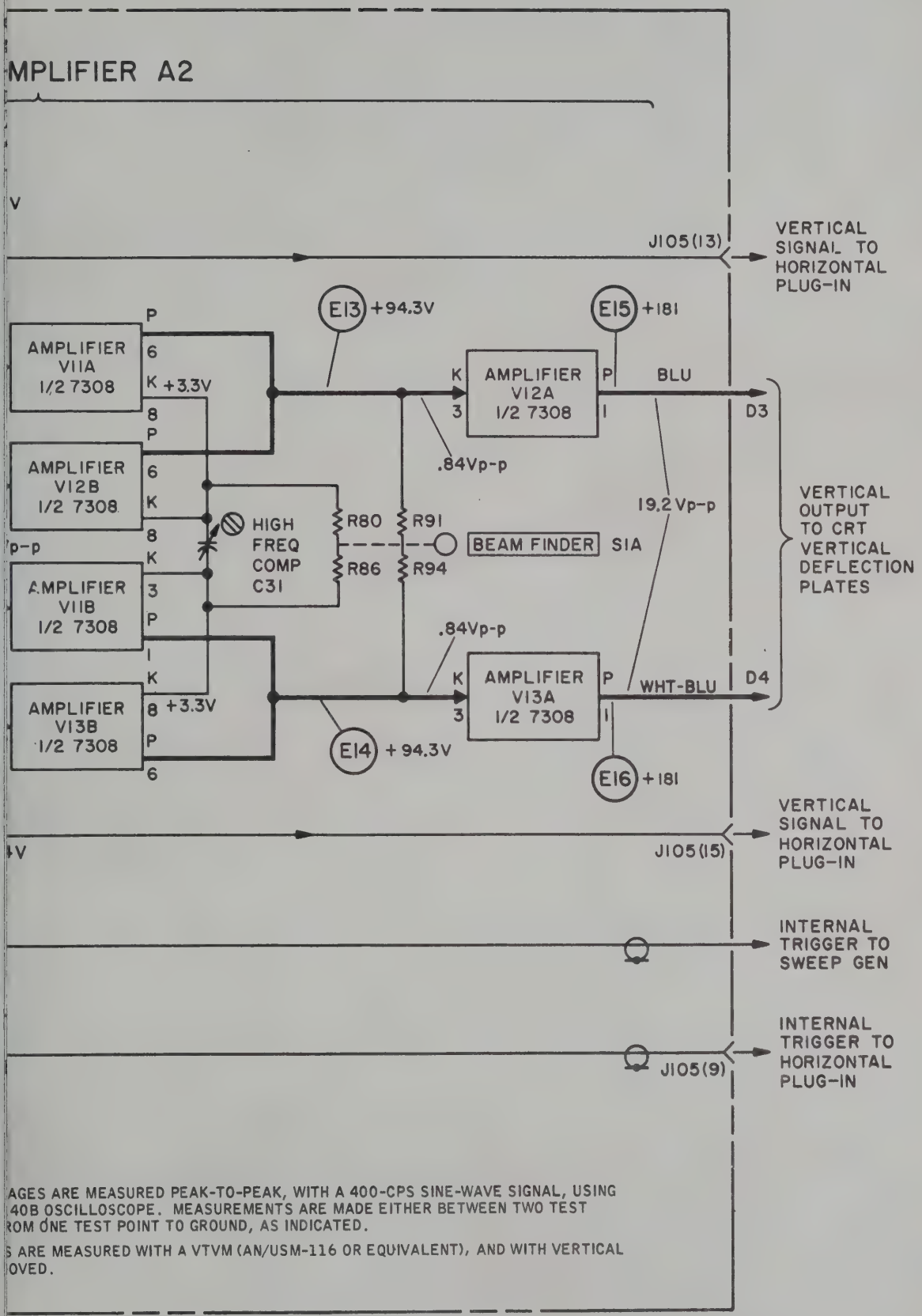


Figure 4-8. Main Vertical Amplifier Functional and Servicing Block Diagram

TABLE 4-5. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
24	Check main vertical amplifier passband as in table 5-7, step 11.	If 3-db point is higher than 30 mc, passband is correct.	
		3-db point is lower than 30 mc	25
25	Make a continuous check of frequency response from 50 kc to 35 mc.	If there are no dips or peaks in response, and 3-db point is higher than 30 mc, response is correct.	
		Dips or peaks present, or 3-db point is lower than 30 mc	26
26	Check DC voltages at test points E15 and E16 with spot centered.	Voltages are +180 volts ±10 volts	27
		If voltages are not +180 volts ±10 volts, make DC measurements throughout the amplifier until fault is located. Correct fault and repeat step 21.	
27	Set up equipment as in table 5-7. Adjust C31 (see Figure 5-3) and vertical deflection plate lead dress for flat top on pulse. Adjust C20, L1, and L2 for best corner on pulse.	If rise time (10-90%) is 11 nanoseconds or less, pulse response is correct.	
		If, with best setting of adjustments, rise time is greater than 11 nanoseconds: a. Check vertical deflection plate leads for poor connections. b. Replace tubes one at a time in the following order: V1, V6, V7, V12, V13, V11, V2, V3, V10, and V4. c. Short out inductor on opposite sides of the amplifier. If shorting on one side has same effect on pulse rise as opposite side, inductors are not faulty. If not, check and replace. Check pairs in the following order: L1 - L2 L3 - L5 L13 - L16 L14 - L17 L6 - L3 L4 - L6 L19 - L20 L21 - L22 d. Check C22 and C25 by paralleling with good one or replacing. e. If there are steps on the pulse top at multiples of 0.2 microseconds apart, replace delay lines.	

Typical DC Voltages in the Vertical Amplifier for the Following Indicated Spot Positions

Test Point	Location	Voltage (Spot 2 cm High) (Spot Center) (Spot 2 cm Low)	Test Point	Location	Voltage (Spot 2 cm High) (Spot Center) (Spot 2 cm Low)
E1	V1(2)	-1.87 -2.07 -2.28	None	V7(6)	+2.4 +1.55 +0.75
E2	V1(7)	-2.28 -2.07 -1.87	E11	V11(7)	+0.75 +1.6 +2.5
E3	V1(3) V2(7)	-0.12 -0.33 -0.55	E12	V11(2)	+2.5 +1.6 +0.75
E4	V1(8) V3(7)	-0.55 -0.33 -0.12	E13	V11(6)	+94.5 +94.3 +94.1
None	V2(6)	+71.6 +71.8 +72	E14	V11(1)	+94.1 +94.3 +94.5
None	V3(6)	+72 +71.8 +71.6	None	V11(8)	+2.5 +3.3 +4.0
E5	V2(1) V6(2)	+149 +150 +151	None	V11(3)	+4.0 +3.3 +2.5
E6	V3(1) V6(7)	+151 +150 +149	E15	V12(1)	+187 +181 +175
E9	V6(3)	+150 +151 +152	E16	V13(1)	+175 +181 +187
E10	V6(8)	+152 +151 +150	E18	V10(8)	+3.1 +4.0 +4.8
None	V7(1)	+0.75 +1.55 +2.4	E19	V10(3)	+4.8 +4.0 +3.1

Conditions of Measurement: Spot set to the three positions using the VERTICAL POSITION control. The voltages shown on the schematic correspond to spot center.

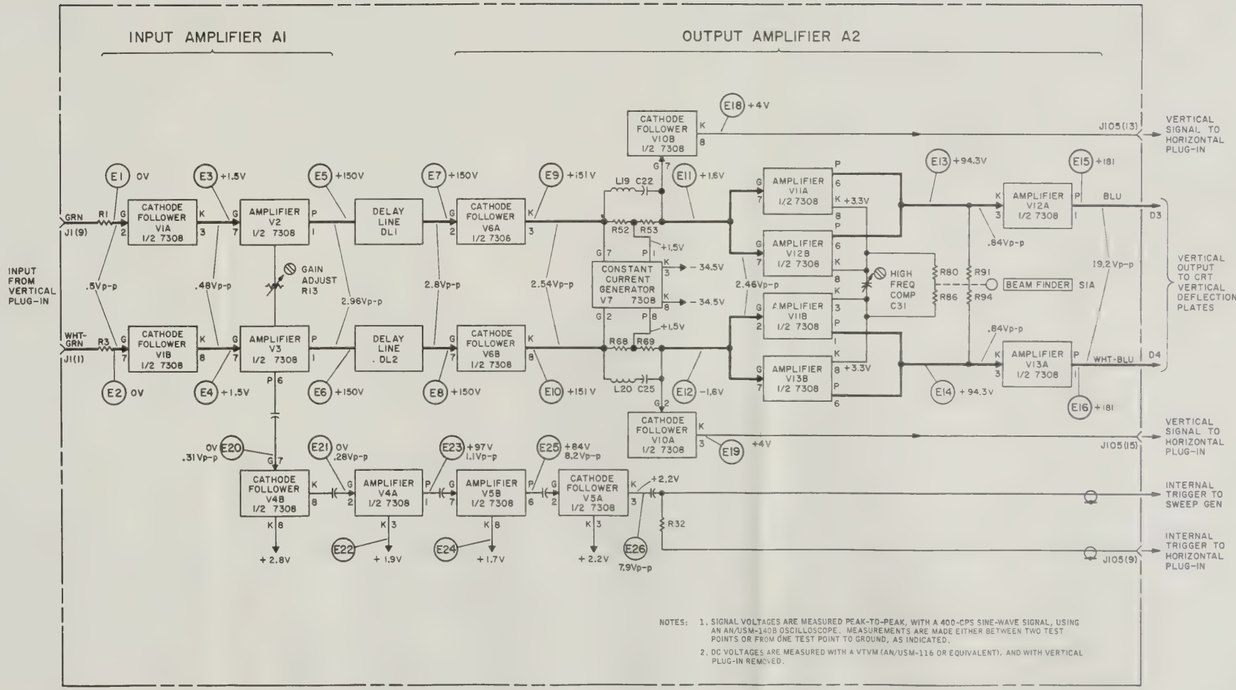


Figure 4-8. Main Vertical Amplifier Functional and Servicing Block Diagram

4-8. HORIZONTAL AMPLIFIER.

a. HORIZONTAL AMPLIFIER FUNCTIONAL DESCRIPTION. The horizontal amplifier amplifies the internal sweep signal or an external signal applied to the horizontal INPUT connector, and drives the horizontal deflection plates of the CRT. The horizontal amplifier consists of three etched circuit boards: A201, located on the bottom (center, front) of the instrument; A203, located perpendicular to A201; and A202, the output circuit, located on the top (center, rear) of the instrument (see figures 5-9 and 5-10).

The Horizontal Amplifier Functional and Servicing Block Diagram is shown in figure 4-9. The sweep signal is applied through the HORIZONTAL DISPLAY switch to cathode follower V201A. From V201A the signal passes through cathode follower V202A and one side of a balanced attenuator to one input of a differential amplifier. Cathode follower V202B controls the second input to the differential amplifier through the other side of the balanced attenuator. The input to cathode follower V202B is grounded through a resistance.

The differential amplifier amplifies the difference between its two input signals and provides a balanced output signal, which is applied to cathode followers V206A and V206B. These cathode followers drive the CRT deflection plates. Cathode follower V206B also drives capacitance driver V207, which acts as the cathode resistance for cathode follower V206A. The capacitance driver, which is effective only at high frequencies due to the small value of coupling-capacitor C216, takes a small amount of signal from the cathode of V206B (positive-going sweep), inverts the signal, and adds it (in-phase) to the negative-going sweep at the cathode of V206A. Cap Driver Adj, C216, adjusts the amount of signal added so that differences in slope at the start of the sweep at both cathodes of V206 are cancelled, resulting in a linear sweep at high sweep speeds.

External horizontal signals applied to the INPUT connector pass through an attenuator, cathode follower V201B, and the HORIZONTAL DISPLAY switch to cathode follower V201A. Otherwise the operation is the same as described above for the sweep signal.

The HORIZONTAL DISPLAY switch selects the signal to be applied to the horizontal deflection plates. The switch also controls the input attenuator and the balanced attenuator. The balanced attenuator provides a means of sweep expansion and in combination with the input attenuator provides steps of external horizontal sensitivity. The EXTERNAL VERNIER control varies the series resistance in the output of cathode follower V201B and thereby varies the output of V201B. The range of the EXTERNAL VERNIER is sufficient to provide continuous adjustment of external horizontal sensitivity between the calibrated settings of the HORIZONTAL DISPLAY switch.

A section of the BEAM FINDER switch is in the common cathode circuit of V204 and V205. When pressed, the switch reduces the gain so that an unbalance prior to V204 and V205 cannot deflect the CRT beam off the screen.

b. HORIZONTAL AMPLIFIER TROUBLE SHOOTING. Trouble symptoms in the horizontal amplifier fall into four classes: (1) the spot cannot be centered horizontally (DC unbalance); (2) high noise level (ripple or microphonics); (3) incorrect midband sensitivity; or (4) poor high-frequency response. Three separate trouble-shooting procedures are given for trouble shooting these problems in the trouble-shooting chart, figure 4-6. The procedure given for trouble shooting for DC unbalance should also be used in trouble shooting for excessive noise level. Before trouble shooting a problem of sensitivity, be sure that the DC balance and the CRT deflection sensitivity are satisfactory (CRT deflection sensitivity can be checked in response to vertical deflection, indicating that proper high-voltage power supply voltages are applied to the CRT). Since high-frequency response depends upon suitable balance and midband sensitivity, the procedure for trouble shooting high-frequency response is presented last in table 4-6, and presumes that the balance and midband sensitivity are properly set. The trouble-shooting techniques upon which the step-by-step procedure of table 4-6 is based are discussed further below. Voltage measurements at test points are shown on both the servicing block diagram (figure 4-9) and the schematic diagram (figure 5-41).

The quickest way to isolate the source of noise or DC unbalance is to connect a jumper across corresponding circuit points on the top and bottom sides of the horizontal amplifier. If so doing eliminates the noise or unbalance, the trouble is ahead of the short; if the trouble symptom persists, the source is after the short. The noise level in the output, across test points C20 and C21, should not exceed 7 millivolts peak-to-peak. Sharp taps on the rear of the chassis should not produce a spot deflection of more than 5-millimeters.

The trouble-shooting procedure given in table 4-6 presents the above method of a "half-split" sequence, i.e., making the first test midway in the amplifier, the second test midway in the amplifier half that is found defective by the first test, and so on. After the trouble is isolated to a stage, the faulty part can be located by making DC voltage measurements and comparing them to the voltages given on the servicing block diagram and the schematic diagram.

Insufficient sensitivity (low gain) in the amplifier is usually caused by a weak tube, incorrect heater, or defective plate supply voltage. The method used to isolate the cause of low sensitivity is to apply a 400-cycle sine-wave signal to the front-panel horizontal INPUT connector and then make AC voltage measurements at the test points shown in the servicing block diagram. Again the "half-split" sequence is used, beginning at the center of the amplifier to determine which half of the amplifier is low in sensitivity, and then going to a point midway in the defective amplifier half. The AC measurements are made across the two sides of the amplifier to simplify the readings. The measuring instrument used must not shift the horizontal position of the trace when it is connected to the circuit. After the stage causing low sensitivity is repaired, apply a 1.0-volt

peak-to-peak input signal with the HORIZONTAL DISPLAY control set to 0.1 VOLTS/CM, and adjust the EXT. GAIN control, R212, to obtain 10-centimeters vertical deflection.

Before trouble shooting a problem of high-frequency response, be sure that the DC balance and midband sensitivity are satisfactory. The test for correct frequency response is to apply a 1-volt peak-to-peak, 400-cycle sine wave to the horizontal INPUT and note the deflection sensitivity as in the previous procedure. Then change the input frequency to 1 megacycle while holding the input level constant, and note how much the deflection sensitivity decreases. The most likely cause of poor high-frequency response is a weak tube or lack of proper circuit adjustment following replacement of a tube.

TABLE 4-6. HORIZONTAL AMPLIFIER TROUBLE SHOOTING

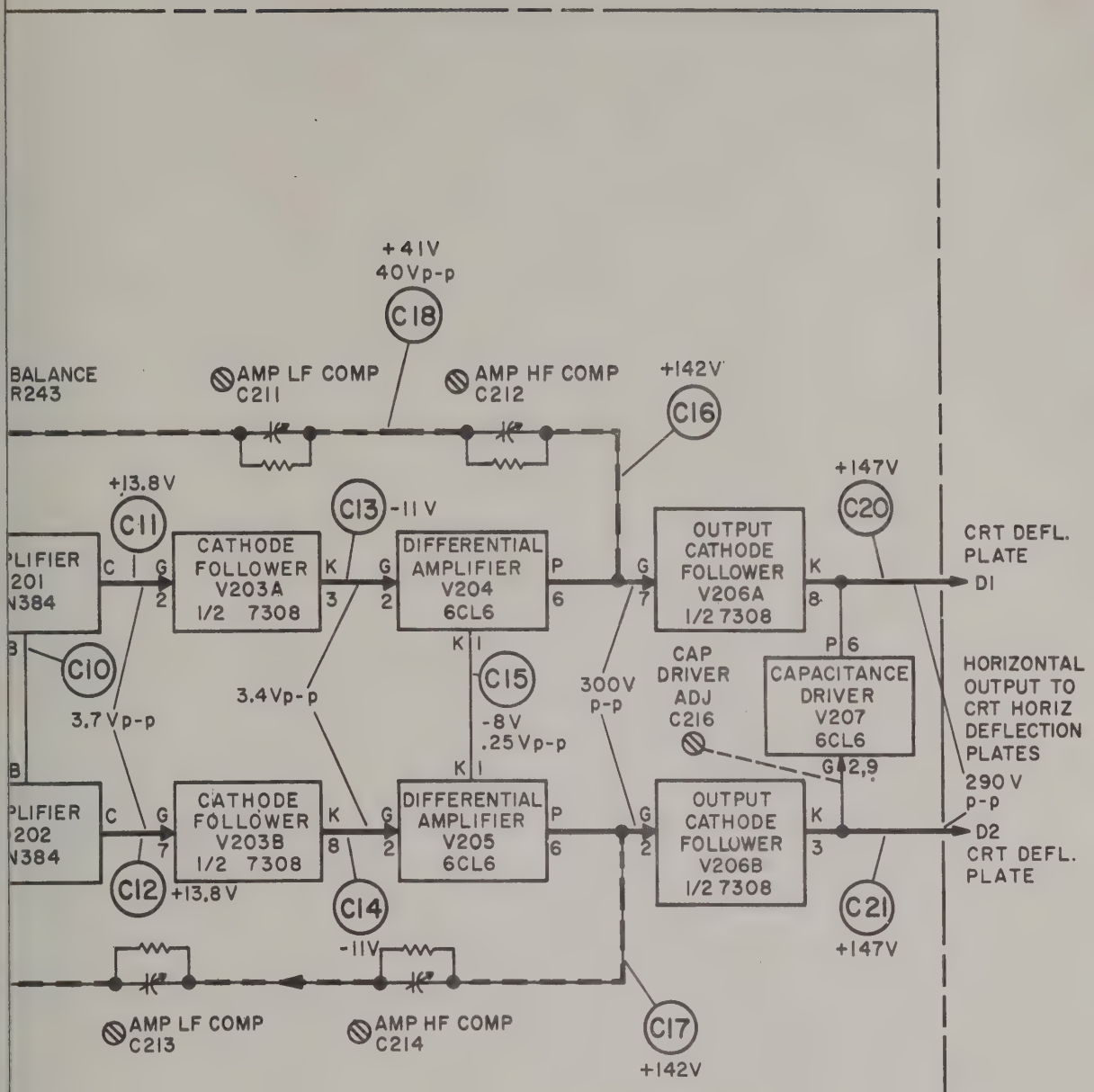
STEP	ACTION	RESULTS	NEXT STEP
		DC UNBALANCE	
1	Set the HORIZONTAL DISPLAY switch between INTERNAL SWEEP X1 and .1 VOLTS/CM positions.	If spot is exactly in the center of the graticule horizontally, DC balance is correct.	
		Spot not centered	2
2	Refer to paragraph 5-4d(1) (Balance) and perform adjustments.	If adjustments put spot exactly in the center of the graticule horizontally, DC balance is correct.	
		Adjustments don't center spot	3
3	Set the HORIZONTAL DISPLAY switch to 0.1. Short test point C13 to C14.	Spot appears on screen	4
		Spot does not appear on screen	7
4	Short test points C11 and C12.	Spot appears on screen	5
		If spot does not appear, check V203 circuit.	
5	Short test points C8 and C9.	Spot appears on screen	6
		If spot does not appear, check Q201 and Q202 circuits.	
6	Short test points C6 and C7.	If spot appears, check attenuator.	
		If spot does not appear, check V202 circuit.	
7	Short test points C16 and C17.	If spot appears, check V204 and V205 circuits.	
		Spot does not appear on screen	8
8	Short test points C20 and C21.	If spot appears, check V206A and B circuits.	
		If spot does not appear, check: a. V207 circuits b. Connections to CRT horizontal deflection plates c. Low-voltage power supply d. High-voltage power supply e. CRT	

TABLE 4-6. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
		SENSITIVITY	
9	Check Horizontal Sensitivity Calibration as in table 5-5, steps 5 and 6.	If horizontal sensitivity meets performance standards, amplifier is correctly set.	
		Horizontal sensitivity does not meet performance standards	10
10	Make Horizontal Amplifier gain and balance adjustments as outlined in paragraph 5-4d.	Gain adjustments can be made	9
		Gain adjustments cannot be made	11
11	Set up equipment as in step 9. Measure the AC voltage between test points C13 and C14 with differential oscilloscope (AN/USM-140B with AM-3567/USM Plug-In).	AC voltage approximately 3.4 volts peak-to-peak	12
		AC voltage less than 3.4 volts peak-to-peak	14
12	Measure the AC voltage between test points C16 and C17.	AC voltage approximately 300 volts peak-to-peak	13
		If AC voltage is less than 300 volts peak-to-peak, check V204 and V205 circuits.	
13	Measure the AC voltage between test points C20 and C21.	If AC voltage is approximately 290 volts peak-to-peak, check: a. Connections to CRT b. DC voltage on CRT horizontal deflection plates c. V207 circuit d. CRT e. High-voltage power supply f. Low-voltage power supply	
		If AC voltage is less than 290 volts peak-to-peak, check circuit around V206A and B	
14	Measure the AC voltage between ground and test points C8 and C9.	AC voltage about 0.19 volt peak-to-peak at C8, and 0.175 volt at C9	15
		AC voltage at C8 and C9 not as above	16
15	Measure the AC voltage between test points C11 and C12.	If AC voltage is approximately 3.7 volts peak-to-peak, check circuit around V203A and B.	
		If AC voltage is less than 3.7 volts peak-to-peak, check circuit around Q201 and Q202.	
16	Measure the AC voltage between test point C5 and ground.	AC voltage approximately 0.4 volt peak-to-peak	17
		AC voltage less than 0.4 volt peak-to-peak	18

TABLE 4-6. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
17	Measure the AC voltage between ground and test points C6 and C7.	If AC voltage is about 0.23 volt peak-to-peak at C6 and 0.13 volt peak-to-peak at C7, check circuit around V202A and B.	
		If AC voltages at C6 and C7 are less than above, check attenuator.	
18	Measure the AC voltage between test point C3 and ground.	If AC voltage is approximately 0.93 volt peak-to-peak, check circuit around V201A.	
		AC voltage less than 0.93 volt peak-to-peak	19
19	Measure the AC voltage between test point C2 and ground.	If AC voltage is approximately 1 volt peak-to-peak, check circuit around V201B.	
		If AC voltage is less than 1 volt peak-to-peak, check set up or input circuit.	
	HIGH FREQUENCY RESPONSE		
20	Set up equipment as in table 5-5.	If frequency at which deflection on CRT decreases to 7.1 cm (3-db point) is greater than 1 mc, horizontal passband is acceptable.	
		3-db point less than 1 mc	21
21	Make adjustments as in paragraph 5-4d(3) (frequency compensation and external frequency compensation).	If adjustments can be made, passband is acceptable.	
		Adjustments cannot be made	22
22	Check DC balance and sensitivity as in DC unbalance, step 1, and table 5-5 horizontal sensitivity calibration.	DC balance and horizontal sensitivity correct	23
		If DC balance and horizontal sensitivity are incorrect, use DC Unbalance and Sensitivity trouble-shooting procedures to isolate the faulty component. Replace faulty component.	21
23	Determine from step 2 if poor passband is in internal horizontal amplifier or external horizontal amplifier only.	Problem in external horizontal amplifier only	24
		Problem in internal horizontal amplifier	25
24	Check V201B and associated circuitry.	Replace deflective component and repeat external frequency compensation, paragraph 5-4d.	
25	Check DC voltage at horizontal deflection plates.	If voltage is +150 volts ±10 volts, check deflection plate lead dress.	
		If voltage is not +150 volts ±10 volts, make DC measurements in amplifier to locate faulty stage. Check stages in the following order: V204, V205, V207, V206, V203, Q201, V202, V201, CRT, and high-voltage power supply.	



VOLTAGES ARE MEASURED PEAK-TO-PEAK, WITH A 400-CPS SINE-WAVE SIGNAL, USING USM-140B OSCILLOSCOPE. MEASUREMENTS ARE MADE EITHER BETWEEN TWO TEST POINTS OR ONE TEST POINT TO GROUND, AS INDICATED.

VOLTAGES ARE MEASURED WITH VTVM (AN/USM-116 OR EQUIVALENT).

MEASUREMENTS MADE WITH EXTERNAL VERNIER CONTROL SET TO "CAL"; AND OTHER SWITCHES AS SHOWN.

Figure 4-9. Horizontal Amplifier Functional and Servicing Block Diagram

TABLE 4-6. (Continued)

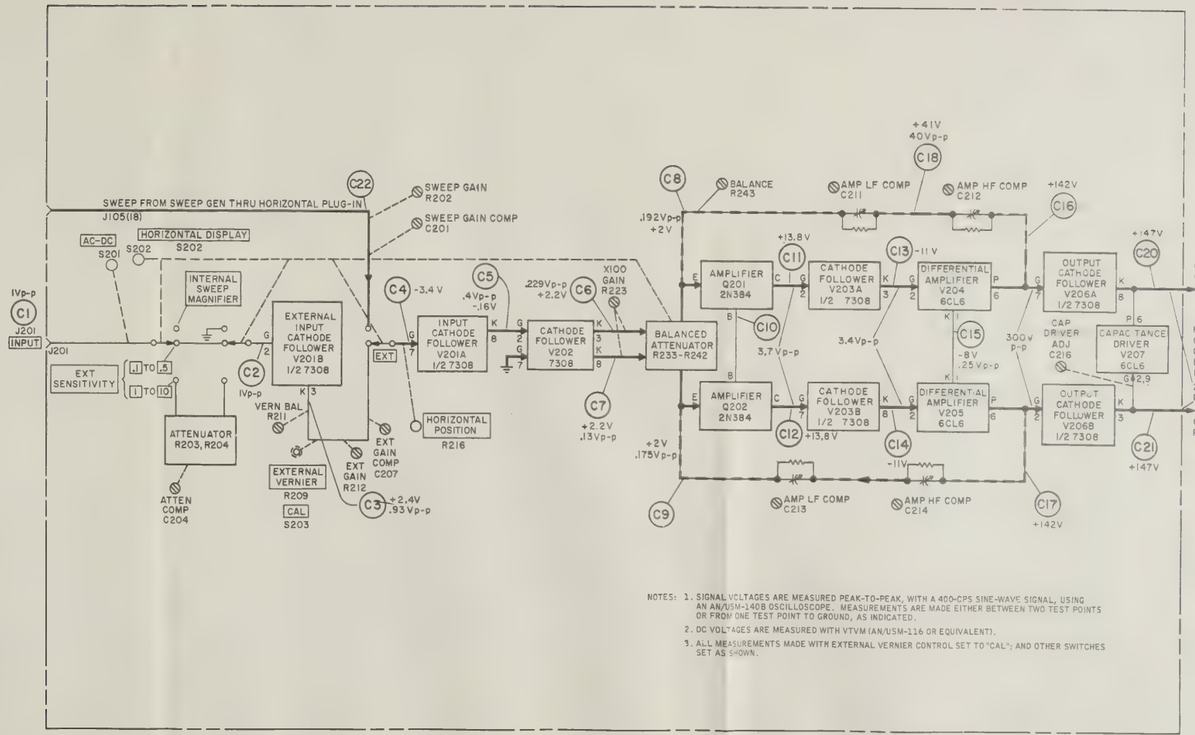
STEP	ACTION	RESULTS	NEXT STEP
17	Measure the AC voltage between ground and test points C6 and C7.	If AC voltage is about 0.23 volt peak-to-peak at C6 and 0.13 volt peak-to-peak at C7, check circuit around V202A and B.	
		If AC voltages at C6 and C7 are less than above, check attenuator.	
18	Measure the AC voltage between test point C3 and ground.	If AC voltage is approximately 0.93 volt peak-to-peak, check circuit around V201A.	
		AC voltage less than 0.93 volt peak-to-peak	19
19	Measure the AC voltage between test point C2 and ground.	If AC voltage is approximately 1 volt peak-to-peak, check circuit around V201B.	
		If AC voltage is less than 1 volt peak-to-peak, check set up or input circuit.	
	HIGH FREQUENCY RESPONSE		
20	Set up equipment as in table 5-5.	If frequency at which deflection on CRT decreases to 7.1 cm (3-db point) is greater than 1 mc, horizontal passband is acceptable.	
		3-db point less than 1 mc	21
21	Make adjustments as in paragraph 5-4d(3) (frequency compensation and external frequency compensation).	If adjustments can be made, passband is acceptable.	
		Adjustments cannot be made	22
22	Check DC balance and sensitivity as in DC unbalance, step 1, and table 5-5 horizontal sensitivity calibration.	DC balance and horizontal sensitivity correct	23
		If DC balance and horizontal sensitivity are incorrect, use DC Unbalance and Sensitivity trouble-shooting procedures to isolate the faulty component. Replace faulty component.	21
23	Determine from step 2 if poor passband is in internal horizontal amplifier or external horizontal amplifier only.	Problem in external horizontal amplifier only	24
		Problem in internal horizontal amplifier	25
24	Check V201B and associated circuitry.	Replace deflective component and repeat external frequency compensation, paragraph 5-4d.	
25	Check DC voltage at horizontal deflection plates.	If voltage is +150 volts ±10 volts, check deflection plate lead dress.	
		If voltage is not +150 volts ±10 volts, make DC measurements in amplifier to locate faulty stage. Check stages in the following order: V204, V205, V207, V206, V203, Q201, V202, V201, CRT, and high-voltage power supply.	

Typical DC Voltages in the Horizontal Amplifier for the Following Indicated Spot Positions

Test Point	Location	Voltage vs Spot Location 2 cm Left	Center	2 cm Right
C4	V201(7)	-3.3	-3.1	-2.9
C5	V202(2)	0.058	-0.16	0.37
C6	V202(3)	+2.1	+2.2	+2.3
C7	V202(8)	+2.3	+2.2	+2.1
C8	Q201(E)	+2.1	+2.2	+2.3
C9	Q202(E)	+2.3	+2.2	+2.1
C10	Q201(B), Q202(B)	+1.9	+2.0	+2.1
C11	Q201(C)	+14.8	+13.8	+12.8
C12	Q202(C)	+12.8	+13.8	+14.8
C13	V204(2,9)	-12	-11	-10
C14	V205(2,9)	-10	-11	-12
C15	V204(1), V205(1)	-8.0	-8.0	-8.0
C16	V206(7)	+217.5	+142	+73
C17	V206(2)	+73	+142	+217.5
C18	R245-R246	+63	+42.	+21
C19	R259-R260	+21	+42.	+63
C20	V206(8)	+225	+147	+75
C21	V206(3)	+75	+147	+225
None	"+370 (B)"	+322	+311	+294

Conditions of Measurement:

Spot set to the three positions using the HORIZONTAL POSITION control; HORIZONTAL DISPLAY switch set to .1 MV/CM; application of the voltmeter test probe shall not deflect the spot. The voltages shown on schematic correspond to spot center.



NOTES: 1. SIGNAL VOLTAGES ARE MEASURED PEAK-TO-PEAK, WITH A 400-CPS SINE-WAVE SIGNAL, USING AN AN/USM-140B OSCILLOSCOPE. MEASUREMENTS ARE MADE EITHER BETWEEN TWO TEST POINTS OR FROM ONE TEST POINT TO GROUND, AS INDICATED.
2. DC VOLTAGES ARE MEASURED WITH VTVM (AN/USM-116 OR EQUIVALENT).
3. ALL MEASUREMENTS MADE WITH EXTERNAL VERNIER CONTROL SET TO "CAL"; AND OTHER SWITCHES SET AS SHOWN.

Figure 4-9. Horizontal Amplifier Functional and Servicing Block Diagram

4-9. SWEEP GENERATOR.

a. SWEEP GENERATOR FUNCTIONAL DESCRIPTION. The sweep generator produces a linear sawtooth waveform for sweeping the spot across the CRT. It also includes the circuit for synchronizing the start of the sawtooth with a specific voltage level on an applied signal. The sweep generator consists of two sections, the sweep generator circuit and the synchronizing circuit, both located on etched circuit A101 on the bottom of the oscilloscope chassis (see figure 5-10). The output of the sweep generator is connected through the HORIZONTAL DISPLAY switch to the horizontal amplifier. The Sweep Generator Functional and Servicing Block Diagram shows the functional circuit arrangement of the sweep generator. The circuits and operating modes are described below.

(1) SYNCHRONIZING CIRCUIT. The synchronizing circuit consists of an input amplifier V101 and a Schmitt trigger V103. The input amplifier is composed of two triodes, V101A and V101B, which receive the input sync signals as selected by TRIGGER SOURCE switch S101. When the amplified signal drives the V103 grid through the lower hysteresis limit, V103 produces a negative pulse at the plate of V103B, which is differentiated by the following coupling network to supply a negative spike to the input grid of V104A/V105A, also a Schmitt trigger.

The Schmitt trigger circuit is a form of bi-stable multivibrator used where fast-rising signals are required. Figure 4-10 shows a simplified Schmitt trigger circuit with input and output waveforms. The output of the circuit is a voltage step, either positive or negative depending upon the slope of the input. The input voltage levels at which a Schmitt trigger circuit switches are its hysteresis limits. Note that the circuit does not switch unless the input crosses both limits.

The TRIGGER LEVEL control sets the zero-signal output level of trigger amplifier V101. Since the trigger amplifier is DC coupled to trigger generator V103, the control determines the voltage levels the trigger signal must cross if the amplified trigger signal is to cross the hysteresis limits of V103. The TRIGGER SLOPE switch determines whether or not the trigger amplifier inverts the trigger signal and thereby determines whether the sweep starts on the positive-going or negative-going portion of the trigger signal.

(2) SWEEP GENERATOR CIRCUIT. Gate generator V104/V105A is a Schmitt circuit with wide hysteresis limits. Between sweeps, the A section of bias control cathode follower V113 holds the bias at the input of the gate generator close to the lower hysteresis limit. Trigger generator V103 applies both positive and negative triggers. The positive triggers are reduced in amplitude and have no effect, but a negative pulse drives the input to the gate generator below the lower hysteresis limit and causes the gate generator to switch.

When it switches, gate generator V104/V105A provides a positive and a negative gate. The positive gate is applied to the high voltage power supply to turn on the CRT beam and to the front-panel GATE OUTPUT connector for external use. The negative gate applies reverse bias to switch diode CR104. Prior to the gate, the switch diode had been forward-biased and had been holding the input to integrator V109 at about zero volts. The negative gate opens the diode switch and frees the input to the integrator.

Once freed, the input to integrator V109 starts going negative because it is connected to -100 volts through the sweep resistor. The integrator amplifies and inverts its input to produce a large, positive-going output which is applied back to the input through cathode follower V115 and the sweep capacitor. As a result, the voltage at the input to integrator V109 changes by about one volt during sweep time. The voltage across the sweep resistor, then, changes by about 1%, and the current through the resistor changes by the same amount. The current through the sweep resistor is the charging current for the sweep capacitor; therefore the voltage across the sweep capacitor changes quite linearly with time, and the sweep signal is a nearly linear voltage ramp.

The SWEEP TIME switch changes the value of sweep resistor or capacitor to change the sweep time. The sweep output is applied to the horizontal amplifier and to the front-panel SWEEP OUTPUT connector.

An attenuated sweep signal is applied to the input of gate generator V104/V105A through hold-off cathode follower V114A and section B of bias control cathode follower V113. This signal drives the input of the gate generator up to the upper hysteresis limit and causes the gate generator to switch back to its pre-sweep state. The gate generator then ends the gates, blanking the CRT and forward-biasing switch diode CR104. The switch diode returns the input to integrator V109 to its pre-sweep level, discharging the sweep capacitor.

During the time period of one sweep, hold-off cathode follower V114A charges a hold-off capacitor. After the sweep ends, this capacitor lets the input to gate generator V104/V105A down slowly enough to prevent that circuit from being triggered again until the remaining sweep circuits have recovered completely. The SWEEP TIME switch changes the size of the hold-off capacitor to match the selected sweep time.

Clamp V105B ensures that each sweep starts from the same voltage level, about -50 volts.

The SWEEP MODE control determines the no-signal bias at the input to gate generator V104/V105A by setting the bias on the A section of bias control cathode follower V113. With the control set to PRESET or in the TRIGGER portion of its adjustable range, the gate generator bias cannot drop below its lower hysteresis limit unless the trigger generator provides a trigger. With the control set in the FREE RUN portion of its adjustable range, the gate bias is allowed to drop below its lower hysteresis limit. Thus as the hold-off capacitor discharges, it lets the gate generator bias all the way down to the lower hysteresis limit, and another sweep starts automatically without requiring a trigger.

(3) SINGLE SWEEP OPERATION. The SWEEP OCCURRENCE switch selects normal or single-sweep operation. Normal operation is discussed above. For single-sweep operation, the

SWEEP OCCURRENCE switch converts V113 into a Schmitt circuit. As the sweep signal from hold-off cathode follower V114A rises to end the gate from the gate generator, the sweep signal also switches the Schmitt circuit of V113 so that V113B conducts and V113A is cut off. The B section of V113 then holds the input to gate generator V104/V105A high enough so that triggers from the trigger generator cannot actuate the gate generator, and the sweep generating circuits are effectively disabled. A positive signal applied to V113A switches the Schmitt circuit of V113 so that V113A conducts and V113B is cut off. The "A" section of V113 then sets the input to the gate generator according to the setting of the SWEEP MODE control, and the sweep generating circuits are effectively armed. The switching signal for V113A can be an external signal applied to the ARMING INPUT connector or an internal signal obtained from the SWEEP MODE control when the control is rotated just out of PRESET.

b. SWEEP GENERATOR TROUBLE SHOOTING. To begin trouble shooting the sweep generator, first determine whether the sync circuit operates satisfactorily by measuring the output waveform at test point D4 (see figure 4-18). AC and DC voltage measurements and waveforms useful in trouble shooting, and conditions for their measurement, are given on both the block diagram (figure 4-11) and the schematic diagram (figure 5-38). If the waveform is not present or is low in amplitude, check AC waveforms in the sync circuit. Waveforms on the schematic are given for a 2-volt peak-to-peak 400-cycle sine-wave input at INPUT J101. If the waveform has the indicated amplitude, an incorrect non-operating sweep will probably be due to a fault in the sweep generator circuit. Trouble symptoms in the sweep circuit fall into three classes: (1) sweep out of calibration, (2) non-linearity, or (3) no sweep. A step-by-step procedure for localizing the cause of a non-operative sweep is given in the trouble-shooting chart for the sweep generator, table 4-7. Trouble shooting techniques for improper calibration and non-linearity, and a further discussion of the technique for localizing the trouble causing a non-operative sweep are given below.

If the sweep rate as measured with a time-mark generator is found to be out of calibration on only certain ranges, the probability is that the adjustment for those ranges is not properly set. If all ranges are out of calibration, the probability is that the horizontal amplifier sensitivity is not properly set or the CRT sensitivity is down.

If the sweep is found to be non-linear, the probability is that the horizontal amplifier or the CRT is defective; check the horizontal amplifier according to its trouble-shooting procedure for poor high frequency response.

If the sweep circuit produces no sweep signal, the first item to check is the waveform at test point D4, to determine whether the gate generator receives an input signal. Then measure the output of the gate generator at test point D11 (see figure 4-18) to see if it has been switched (-6.8 volts if it has; -3.6 volts if it has not). If the gate generator has not been switched, check tubes in gate and hold-off circuits (V104, V105, V113, and V114). If the gate generator has been switched, check tubes and diodes in the integrating circuit (V109, V115, V105B, CR103, and CR104). A non-operating sweep can be caused by faults other than defective tubes. Table 4-7 gives a systematic procedure for locating the cause of a non-operating sweep.

USEFUL ILLUSTRATIONS OF THE SWEEP GENERATOR

Illustration	Figure No.	Page No.
Block Diagram	4-11	4-39, 4-40
Location of Test Points	4-18	4-51
Location of Parts	5-17 through 5-20	5-33 and 5-34
Schematic Diagram	5-38	5-61, 5-62
Sweep-Time Switch Functional Schematic Diagram	5-39	5-63, 5-64

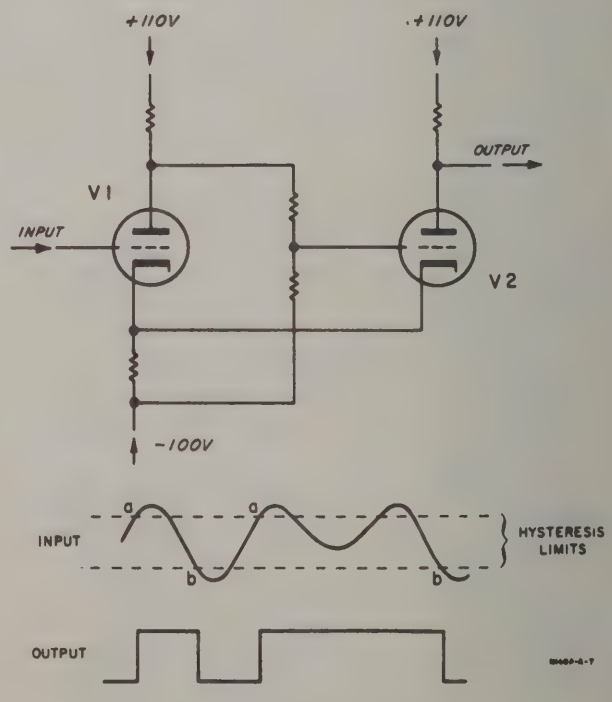


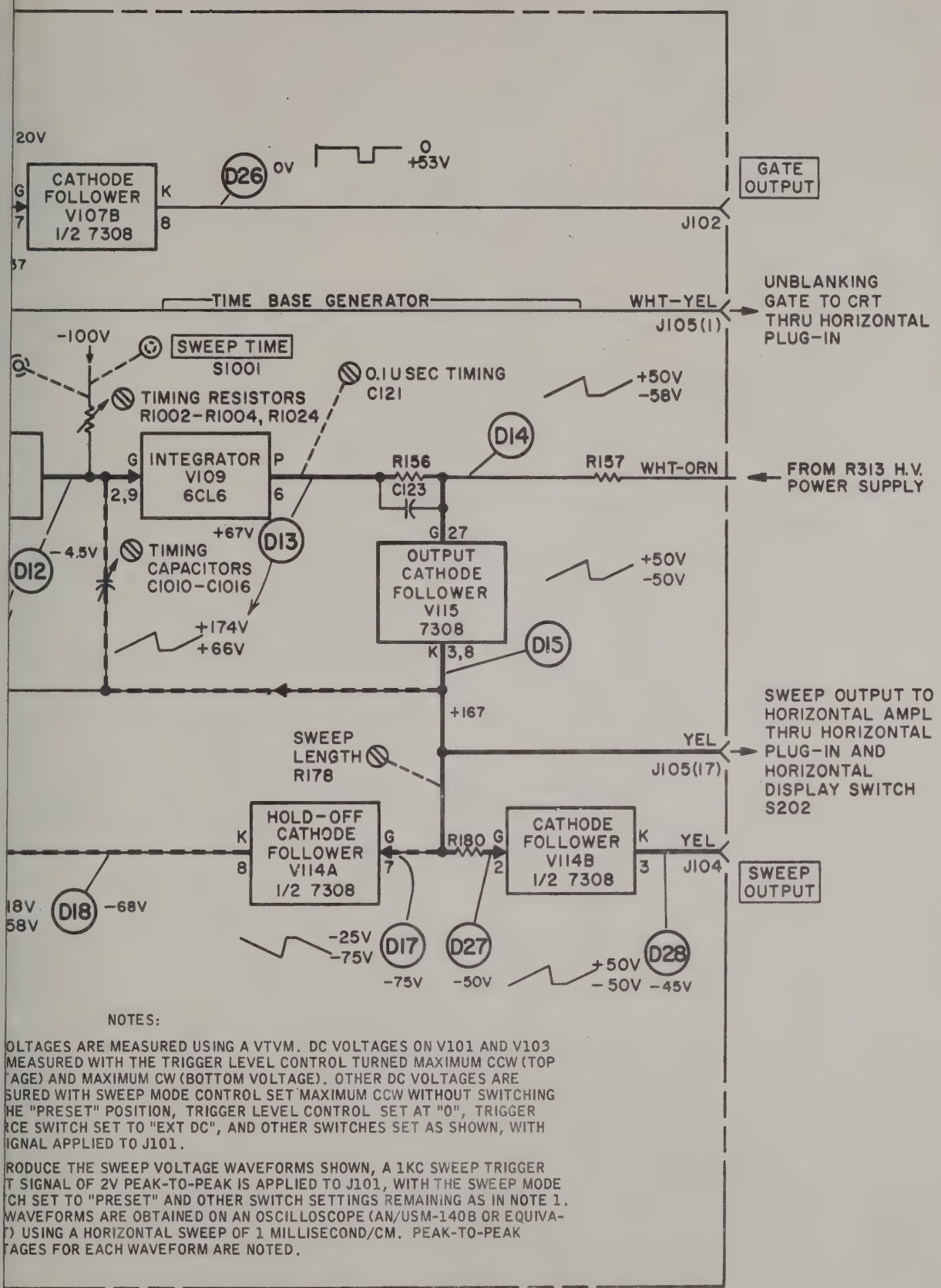
Figure 4-10. Schmitt Trigger Simplified Circuit with Waveforms

TABLE 4-7. SWEEP GENERATOR TROUBLE SHOOTING

STEP	ACTION	RESULTS	NEXT STEP
		NO SWEEP	
1	Unsolder the C109 end of R124.		2
2	With a clip lead, connect R124 to ground then -100 volts. Measure the DC voltage at test point D15.	DC voltage changes from -50 volts to +84 volts	3
		Not as above	9
3	Same as step 2. Measure the DC voltage at test point D19.	-67 volts to -3 volts	4
		Not as above	6
4	Same as step 2. Measure the DC voltage test point D6.	-38 volts to -5 volts	5
		Not as above	8
5	Same as step 2. Measure the DC voltage test point D21.	+9 volts (normal)	
		If not +9 volts, SWEEP MODE is not in PRESET, or problem is in preset circuit or V113A.	
6	Same as step 2. Measure the DC voltage at test point D17.	-75 volts to -8.4 volts	7
		If not as above, check sweep length circuit.	
7	Same as step 2. Measure the DC voltage at test point D18.	If voltage is -67 volts to -3 volts, check horizontal plug-in connections (be sure plug-in is set for NORMAL sweep).	
		If not as above, check V114A circuit.	
8	Same as step 2. Measure the DC voltage at test point D20.	If -38 volts to -.04 volt, V113B is operating correctly.	
		If not as above, check V113 circuit.	
9	Same as step 2. Measure the DC voltage at test point D11.	-4.2 volts to -6.6 volts	10
		If not as above, refer to steps 14 and 16, or check CR103.	
10	Same as step 2. Measure the DC voltage at test point D13.	+67 volts to +332 volts	11
		Not as above	12
11	Same as step 2. Measure the DC voltage at test point D14.	If -58 volts to +83 volts, check V115 circuit.	
		If not as above, check circuit around R156, C123, R157, and R313, or high-voltage power supply.	
12	Same as step 2. Measure the DC voltage at test point D12.	If -4.6 to -7.0 volts, check V109 circuit.	
		If not as above, check CR104 circuit.	
13	Same as step 2. Measure the DC voltage at test point D16.	If -50.8 volts to -52.0 volts, check CR103 and V105B circuit.	
		Not as above	14

TABLE 4-7. (Continued)

STEP	ACTION	RESULTS	NEXT STEP
14	Same as step 2. Measure the DC voltage at test point $\overline{D8}$.	+7.8 volts to +110 volts	15
		If not as above, check V105 circuit, V104A/B circuit, and CR101.	
15	Same as step 2. Measure the DC voltage at test point $\overline{D9}$.	If -51.7 volts to -16.7 volts, check V105A circuit.	
		Not as above	16
16	Same as step 2. Measure the DC voltage at test point $\overline{D10}$.	If -1.83 volts to -17.6 volts, check V104B.	



NOTES:

OLTAGES ARE MEASURED USING A VTVM. DC VOLTAGES ON V101 AND V103 MEASURED WITH THE TRIGGER LEVEL CONTROL TURNED MAXIMUM CCW (TOP 'AGE) AND MAXIMUM CW (BOTTOM VOLTAGE). OTHER DC VOLTAGES ARE SURED WITH SWEEP MODE CONTROL SET MAXIMUM CCW WITHOUT SWITCHING HE "PRESET" POSITION, TRIGGER LEVEL CONTROL SET AT "0", TRIGGER RCE SWITCH SET TO "EXT DC", AND OTHER SWITCHES SET AS SHOWN, WITH IGNAL APPLIED TO J101.

RODUCE THE SWEEP VOLTAGE WAVEFORMS SHOWN, A 1KC SWEEP TRIGGER T SIGNAL OF 2V PEAK-TO-PEAK IS APPLIED TO J101, WITH THE SWEEP MODE CH SET TO "PRESET" AND OTHER SWITCH SETTINGS REMAINING AS IN NOTE 1. WAVEFORMS ARE OBTAINED ON AN OSCILLOSCOPE (AN/USM-140B OR EQUIVA-T) USING A HORIZONTAL SWEEP OF 1 MILLISECOND/CM. PEAK-TO-PEAK TAGES FOR EACH WAVEFORM ARE NOTED.

Figure 4-11. Sweep Generator Functional and Servicing Block Diagram

TABLE 4-7. (Continued)

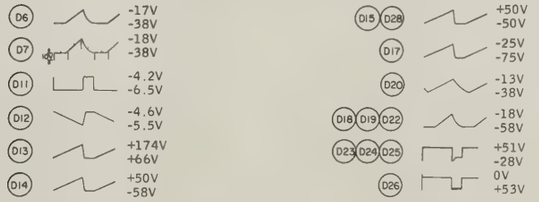
STEP	ACTION	RESULTS	NEXT STEP
14	Same as step 2. Measure the DC voltage at test point $\overline{D8}$.	+7.8 volts to +110 volts	15
		If not as above, check V105 circuit, V104A/B circuit, and CR101.	
15	Same as step 2. Measure the DC voltage at test point $\overline{D9}$.	If -51.7 volts to -16.7 volts, check V105A circuit.	
		Not as above	16
16	Same as step 2. Measure the DC voltage at test point $\overline{D10}$.	If -1.83 volts to -17.6 volts, check V104B.	

Supplementary Troubleshooting Voltages for
Non-Operating Sweep

NOTE: Voltages measured by disconnecting R124 from TP D7 and with a clip lead alternately connecting R124 to -100 volts (from any violet lead) and then momentarily to ground; voltage measured for each state with the voltage measured in the grounded condition listed first.

Test Point	Location	Voltage (R124 grounded) (R124 at -100V)	Test Point	Location	Voltage (R124 grounded) (R124 at -100V)
D6	R171	-38. -5.3	D16	V105(7)	-51 -52.
D7	V104(7)	-0.36 v -100. v	D17	R175	-75. -8.4
D8	V104(6)	+8. +110.	D18	V114(8)	-66. -3.
None	V104(2)	-22.9 +50.6	D19	V113(7)	-66. -3.
D9	V105(2)	-51. -17.	D20	V113(8)	-38. -0.04
D10	V105(3)	-1.8 -17.	D21	V113(1)	-7. +82.
D11	V105(1)	-4.2 -6.5	D22	see D19	
D12	R151	-4.6 -7.	D23	V107(2)	-20. +51.
D13	V109(6)	+66.5 +332.	D24	V107(3)	-16. +52.
R157 junction with WHT-ORN lead		+95. +36.	D25	V107(7)	-15. +50.
D14	R155	-58. +83.	D26	V107(8)	0 +53.
D15	V115(8)	-51. +85.	D27	V114(2)	-51. +80.
			D28	V114(3)	-46. +81.

Waveforms for Test Points Indicated



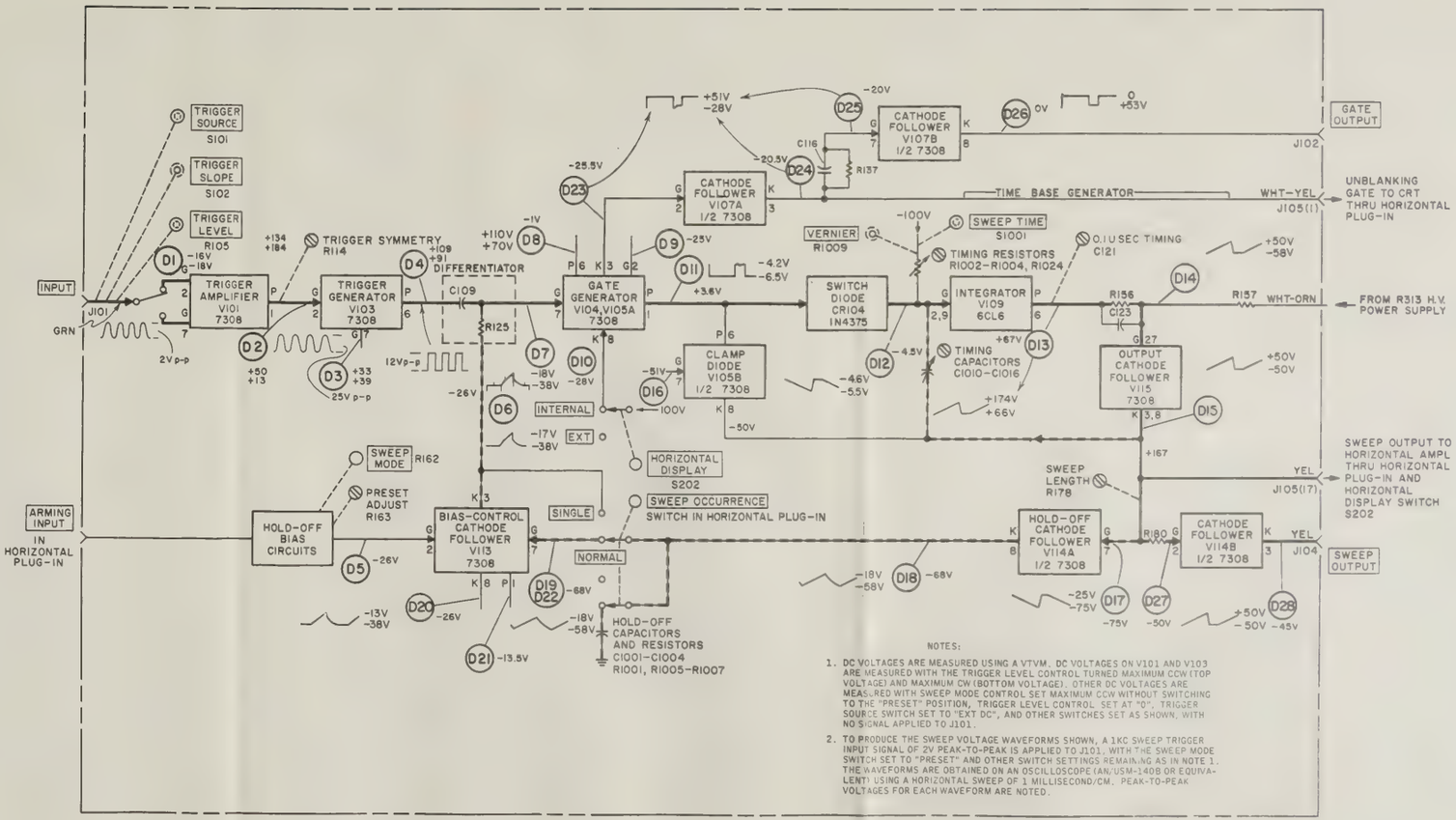


Figure 4-11. Sweep Generator Functional and Servicing Block Diagram

4-10. CALIBRATOR CIRCUIT.

a. CALIBRATOR CIRCUIT FUNCTIONAL DESCRIPTION. The calibrator is located on the high-voltage power supply etched circuit assembly, and is shown on the schematic diagram for the high voltage power supply, figure 5-43. It consists of a type 7308 tube (V306) connected as a free-running 1KC multivibrator, a diode clamp V307A to limit the positive-going voltage at the output plate of the multivibrator, and a second diode V307B in series with the output signal to prevent the voltage at the CALIBRATOR output connectors from going negative as the output plate passes the 0-volt level during half of the cycle. Thus, the calibrator circuit produces an output 1KC square wave voltage which is clipped on negative and positive peaks at 0 and +110 volts. This output is applied to an attenuator which provides calibrated outputs in volts and millivolts. When the CALIBRATOR switch is set to OFF, the output side of the multivibrator is cut off by an applied grid bias of -100 volts.

b. CALIBRATOR CIRCUIT TROUBLE SHOOTING. Problems in the calibrator fall into four categories: (1) no output, (2) poor symmetry and/or period, (3) low amplitude on all ranges, or (4) poor calibration on some ranges. Table 4-8 is the trouble-shooting chart for the calibrator circuit.

In all cases of trouble, except for poor calibration on only some of the ranges (category 4), first check tubes V306 and V307 while observing the output waveform and the output plate waveform as instructed in the procedure of table 4-8. Although tube element voltages are shown in the schematic diagram for the calibrator, practically all troubles will be found by replacing tubes and observing the output waveform. Poor calibration on only certain ranges almost certainly points to damaged resistors in the range selector switch S302.

WARNING

Very high voltages are present in the vicinity of the calibrator circuit. Turn off the oscilloscope when making connections.

TABLE 4-8. CALIBRATOR CIRCUIT TROUBLE SHOOTING

STEP	ACTION	RESULTS	NEXT STEP
1	Check calibrator waveform at CALIBRATOR OUTPUT (test point F1).	No output	2
		Symmetry not within 45% to 55%	3
		Period not within 0.9 to 1.1 milliseconds	3
		Amplitude not within ±3% on all ranges	3
		Poor waveform	3
		Amplitude not within ±3% on certain ranges	4
2	Check waveform at test point F3 or F5	If waveform is as indicated on schematic, check V307 by replacement.	
		If waveform is incorrect, check V306 by replacement.	
3	Check V306 and V307 by replacement, and observe output waveform.	If no improvement, check resistors and capacitors in multivibrator circuit.	
4	Turn instrument off and measure resistors on CALIBRATOR range switch.	If comparison with the values shown on the schematic diagram shows a value to be in error, replace the resistor.	

4-11. MX-2930B/USM VERTICAL PLUG-IN UNIT.

a. MX-2930B/USM VERTICAL PLUG-IN FUNCTIONAL DESCRIPTION. This Dual-Trace Preamplifier vertical plug-in unit receives one or two input signals from external sources, amplifies them, combines them in one of four different ways, and applies them to the main vertical amplifier input. The plug-in contains two separate differential amplifiers on etched circuit A501 and a switching circuit on etched circuit A502. The outputs of both amplifier channels are connected in parallel, and each provides a balanced output to drive the main vertical amplifier. The front-panel Vertical Presentation Switch (S505), however, allows only one amplifier to operate at a time. S505 operates the switching circuit to turn on either one amplifier or the other (individual Channel A or Channel B operation), or to alternately turn on one amplifier during one sweep and the other amplifier on the next sweep (ALTERNATE operation), or to turn on the amplifiers alternately in 1-microsecond segments during each sweep (CHOPPED operation). A fourth mode of operation, A-B, connects the A and B channel inputs to opposite sides of the Channel A differential amplifier.

The Vertical Plug-In Functional and Servicing Block Diagram, figure 4-13, gives a simplified version of the circuits and switching arrangements. Basically, the circuit consists of two identical input attenuators, two identical amplifier channels, and a switching circuit as described in detail below.

(1) INPUT ATTENUATORS. Each input attenuator divides its signal in a calibrated ratio for each setting of the SENSITIVITY switch to give sensitivities of 0.02 to 20 volts per centimeter. Except for the 0.02 VOLTS/CM range, each range is provided with a compensating attenuator (Atten Comp) to maintain these ratios for high frequencies by capacitive division. Each range also has a capacitor (Cap. Adj) for adjusting input capacity, so that frequency compensation with the test prod will be constant on all ranges.

(2) AMPLIFIERS. Each of the two amplifying channels consists of four stages: two balanced cathode follower stages, a common-base transistor amplifier, and a balanced output cathode follower stage. The SENS CAL control, R504 (R546), varies the bias on the second cathode follower stage, causing a gain variation of between 0.4 and 0.7. The BAL control, R508 (R543), balances the DC levels at the cathodes of V502A/B (V505A/B), so that no vertical shift takes place when the POLARITY switch is operated. The signal from V502A/B (V505A/B) drives the emitters of the transistor amplifier Q501/Q502 (Q503, Q504). This stage is controlled by the switching circuit, being either cut off or operating as determined by the bias supplied through CR501 (CR505). The output cathode followers drive the main vertical amplifier in the AN/USM-140B. The VERTICAL POSITION control, R520 (R530), varies the DC levels at the grids of V503A/B (V506A/B), and since the main vertical amplifier is also DC-coupled, these DC levels will determine the vertical position of the trace on the CRT.

(3) SWITCHING CONTROL CIRCUIT. The switching control circuit consists of a multivibrator, an amplifier, and a Vertical Presentation Switch. With the Vertical Presentation Switch at position A, both the input and output of the switch signal amplifier are disconnected, and the signal from input A is connected to the A Channel amplifier (V501A/B), and the input B to the B Channel (V504A/B) amplifier. Negative bias is applied to switch off the B half (V508B) of the multivibrator. CR505 conducts, applying a positive voltage to the bases of transistors Q503, Q504, thereby switching off Channel B. With the A half (V508A) conducting, diode CR501 cuts off, and with Q501, Q502 conducting, Channel A is free to amplify the signal from input A. The reverse is true with the Vertical Presentation Switch on position B.

On CHOPPED, the negative bias is eliminated, and the switching multivibrator free runs at a frequency set by C509 and C510, switching on and off Channels A and B. Breakdown diode CR506 limits the saturation to assure the multivibrator self-starting. During chopping, the transient at the beginning of each chop is high. Blanking out the oscilloscope trace at such times erases the transients from observation, and the smooth chopped traces shown in figure 4-18 result. The blanking signal to the CRT is derived from the switching multivibrator, transferred through CR502 and CR503, amplified by V507A, and isolated by cathode follower V507B. Diode CR504 clips off all the negative pulses; the positive pulses are applied to the cathode of the CRT to blank the switching transient.

On A-B, the switching multivibrator switches Channel A on and Channel B off. The signal input to B is applied to the lower half of differential amplifier A, and the differential input, Channel A minus Channel B, is amplified and presented.

On ALTERNATE, the switching multivibrator is rendered bi-stable by applying negative bias on both halves. Pulses, from the oscilloscope, and synchronized with the horizontal sweep signal, are amplified by the switch signal amplifier (V507A/B) to trigger the switching multivibrator, presenting the signals A and B on the screen on alternate sweeps.

b. MX-2930B/USM VERTICAL PLUG-IN TROUBLE SHOOTING. Trouble shooting the vertical plug-in unit presumes that the main vertical amplifier in the oscilloscope is known to be operating satisfactorily. Trouble symptoms in the plug-in unit fall into six classes: (1) the spot cannot be centered vertically (DC balance) in one of the channels; (2) high noise level (ripple or microphonics) in one of the channels, (3) midband sensitivity is low in one of the channels, (4) poor high-frequency (pulse) response, (5) no ALTERNATE operation, or (6) no CHOPPED operation.

Test points and voltage measurements that are useful in trouble shooting are shown on the servicing block diagram, figure 4-13 and the schematic diagram, figure 5-46. A vertical plug-in extender which permits operation of the vertical plug-in unit outside the chassis for convenient access to test points, etc., can be constructed as shown in figure 4-12.

The first step in trouble shooting is to determine if the trouble symptom occurs in one or both of the amplifier channels or in the switching circuit. To determine if the switching circuit operates, measure its tube socket voltages and compare them against those given in the block diagram or schematic diagram.

For the switching multivibrator to turn on the Channel A (Channel B) amplifier, a negative voltage must appear at the plate of V508B (V508A). When the Vertical Presentation Switch is set to ALTERNATE, each unblanking pulse from the sweep generator must cause V508 to switch from one state to the opposite state. When set to CHOPPED, V508 must oscillate at approximately 1 megacycle. To trouble shoot either of the amplifiers, refer to the trouble-shooting data given for the main vertical amplifier.

The quickest way to isolate the source of noise or DC unbalance in either of the amplifiers is to connect a jumper across the corresponding circuit test points on the top and bottom sides of the amplifier. If so doing eliminates the noise or unbalance, the trouble is ahead of the short; if the trouble symptom persists, the trouble is after the short.

Before trouble shooting a problem of sensitivity, be sure that the DC balance is satisfactory, and that the main vertical amplifier sensitivity is properly set. Low gain in the amplifier is usually caused by a weak tube or transistor or incorrect supply voltages. AC measurements for obtaining the gain of each stage are given in the block diagram, for an input of 0.05 volts peak-to-peak. Use a differential oscilloscope (AN/USM-140B with AM-3567/USM Plug-In) for measuring low-level peak-to-peak voltages between test points indicated. Progress in numerical order through both amplifiers until the low gain stage is located. Set the Vertical Presentation Switch to the appropriate channel position for measuring channel gain.

Before trouble shooting a problem of high-frequency response, be sure that the attenuator compensation adjustments are correctly set, and that DC balance, R508 (R543), and midband sensitivity, R504 (R546), are satisfactory. The most likely cause of inadequate high-frequency response is a defective tube or transistor or lack of proper circuit adjustment following replacement of a tube or transistor. Be sure that L501, L502, L511, and L512 have been correctly set.

USEFUL ILLUSTRATION OF THE MX-2930B/USM VERTICAL PLUG-IN

Illustration	Figure No.	Page No.
Block Diagram	4-13	4-45, 4-46
Location of Test Points	4-21 4-22	4-54 4-54
Location of Parts	5-30 through 5-34	5-49 through 5-55
Schematic Diagram	5-46	5-77, 5-78

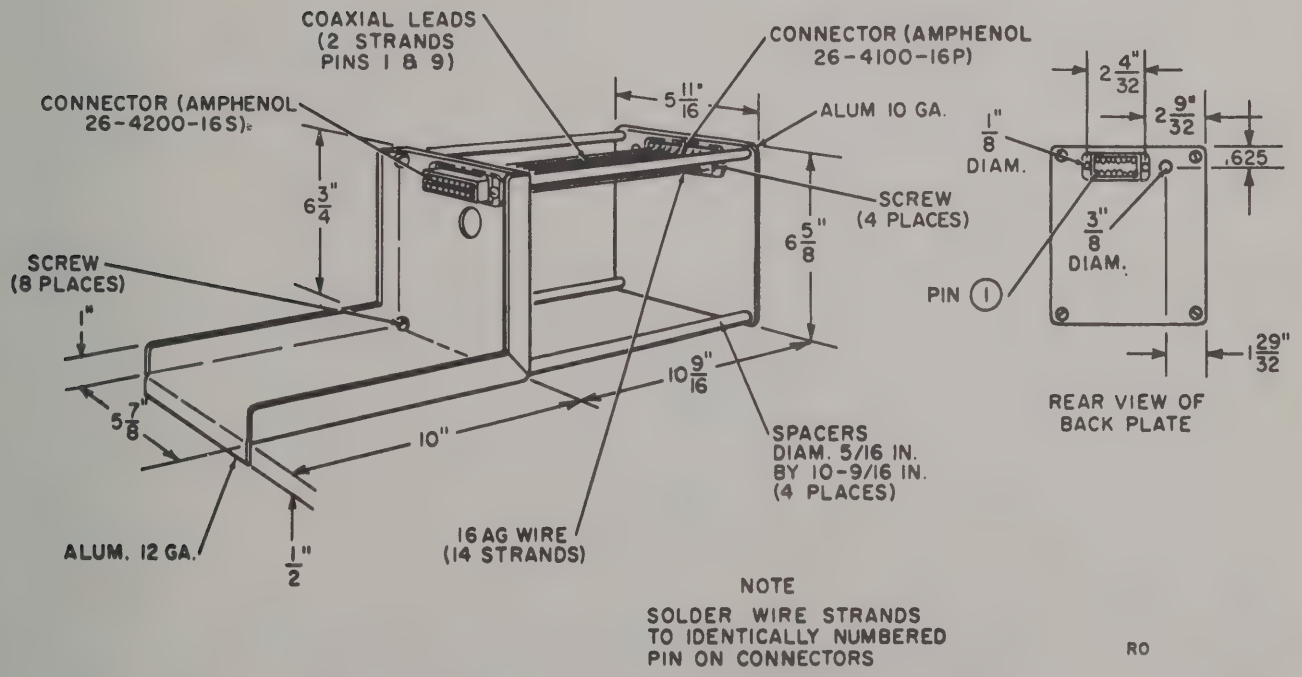


Figure 4-12. Construction of Vertical Plug-In Extender 162A-39A

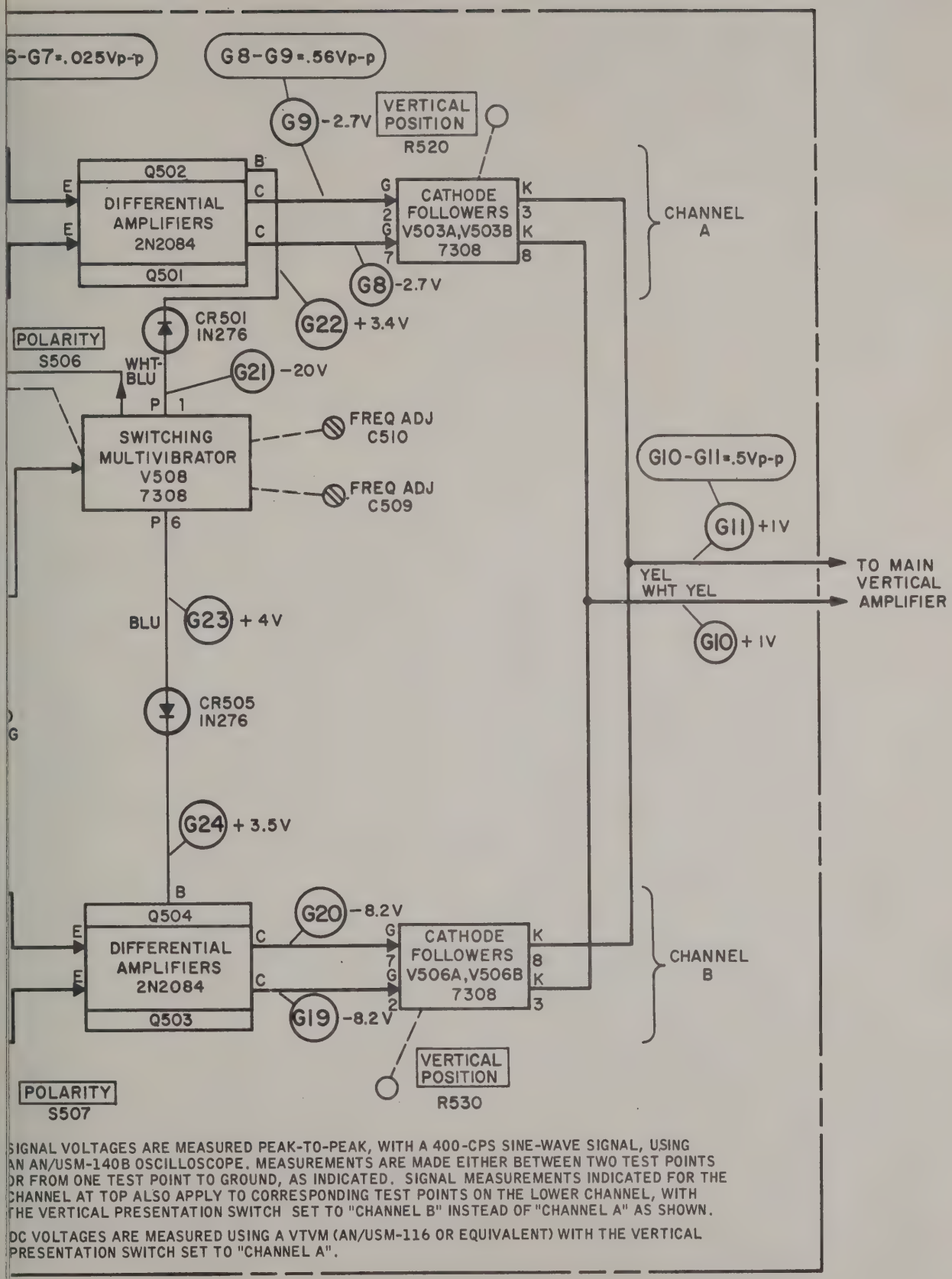
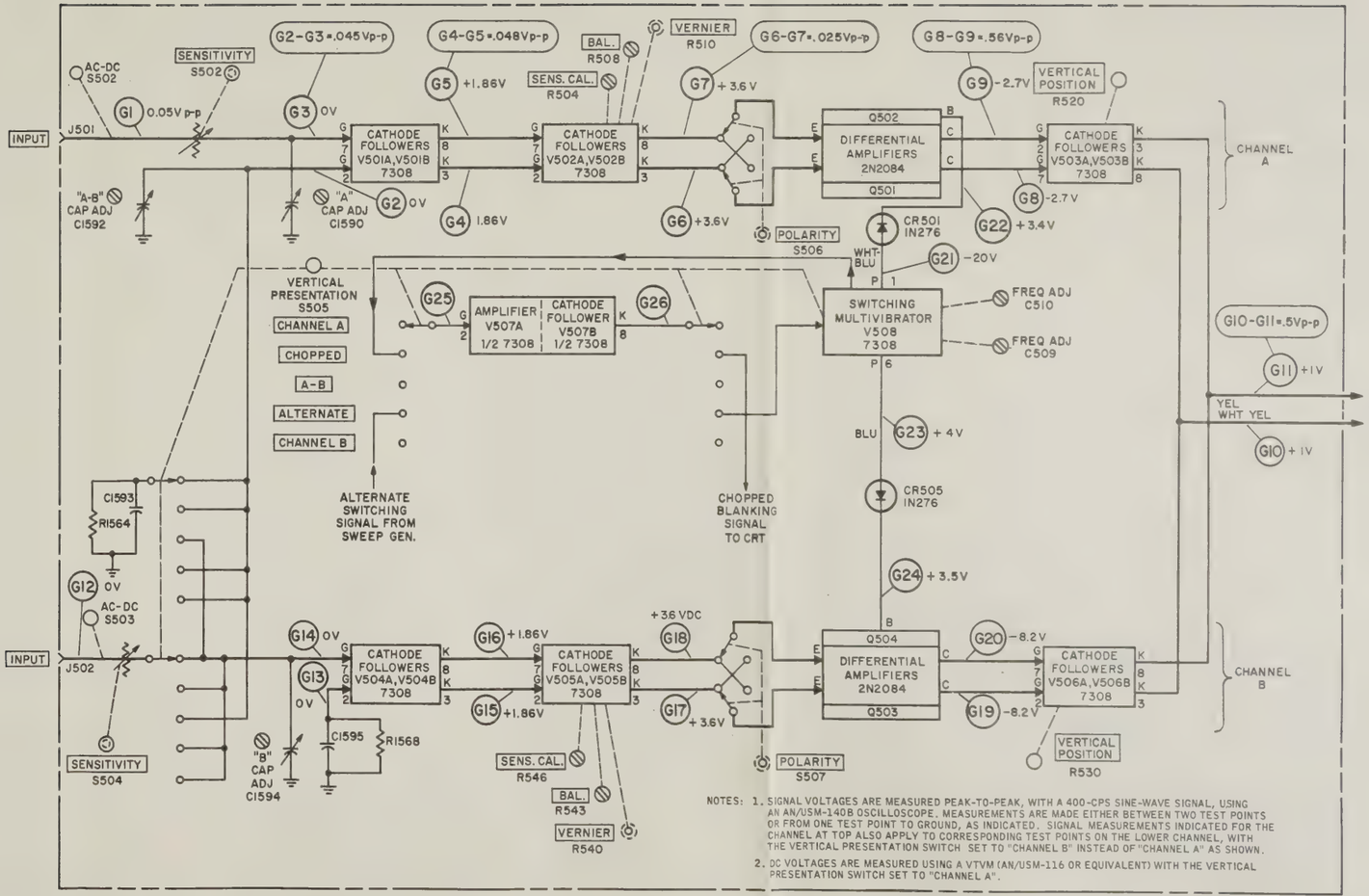


Figure 4-13. Vertical Plug-In Functional and Servicing Block Diagram



NOTES: 1. SIGNAL VOLTAGES ARE MEASURED PEAK-TO-PEAK, WITH A 400-CPS SINE-WAVE SIGNAL, USING AN AN/USM-140B OSCILLOSCOPE. MEASUREMENTS ARE MADE EITHER BETWEEN TWO TEST POINTS OR FROM ONE TEST POINT TO GROUND, AS INDICATED. SIGNAL MEASUREMENTS INDICATED FOR THE CHANNEL AT TOP ALSO APPLY TO CORRESPONDING TEST POINTS ON THE LOWER CHANNEL, WITH THE VERTICAL PRESENTATION SWITCH SET TO "CHANNEL B" INSTEAD OF "CHANNEL A" AS SHOWN.

2. DC VOLTAGES ARE MEASURED USING A VTVM (AN/USM-116 OR EQUIVALENT) WITH THE VERTICAL PRESENTATION SWITCH SET TO "CHANNEL A".

Figure 4-13. Vertical Plug-In Functional and Servicing Block Diagram

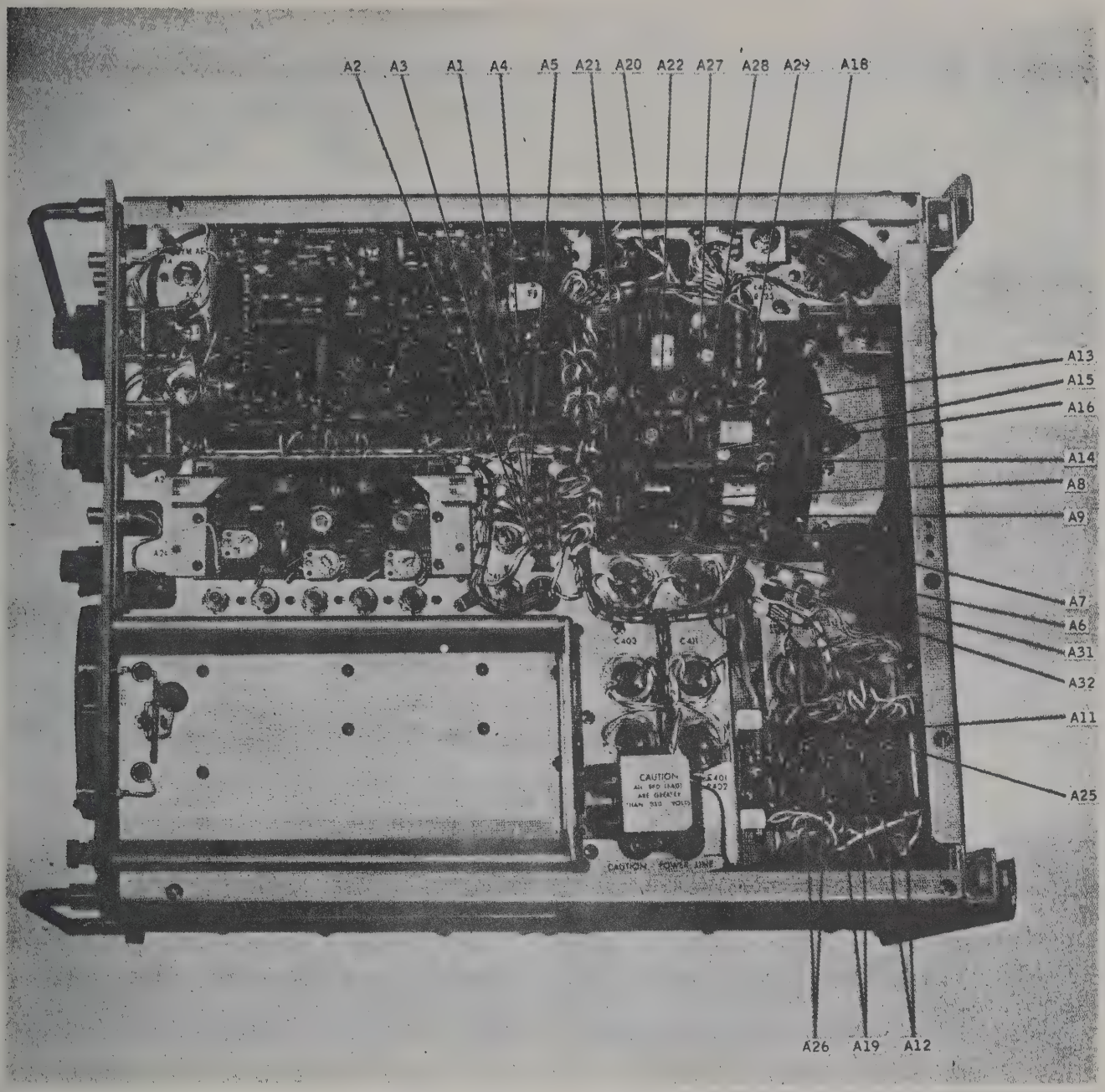


Figure 4-14. Bottom View, Location of Test Points on Low-Voltage Power Supply

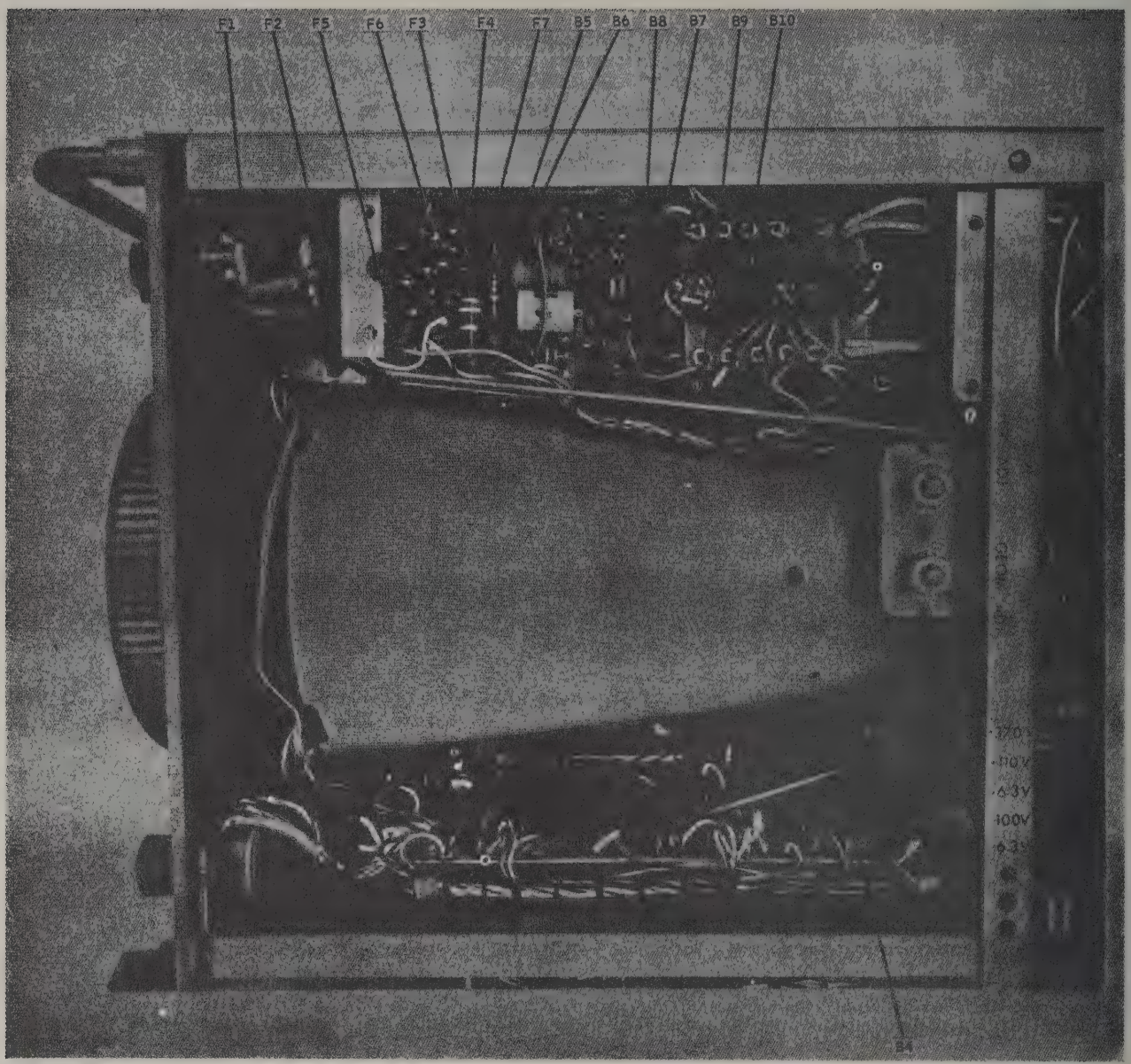


Figure 4-15. Top View, Location of Test Points on High-Voltage Power Supply

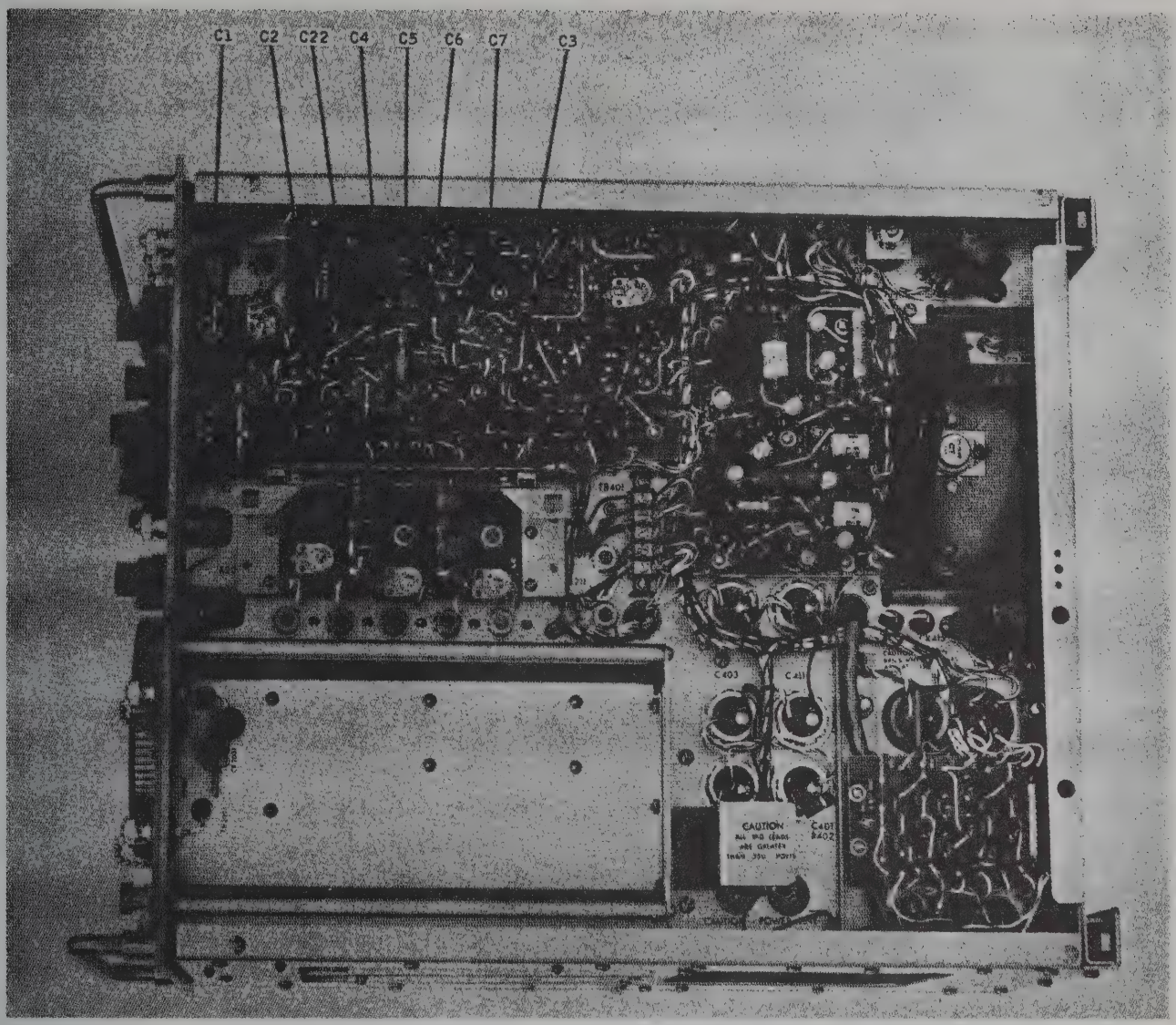


Figure 4-16. Bottom View, Location of Test Points on Horizontal Preamplifier Assembly

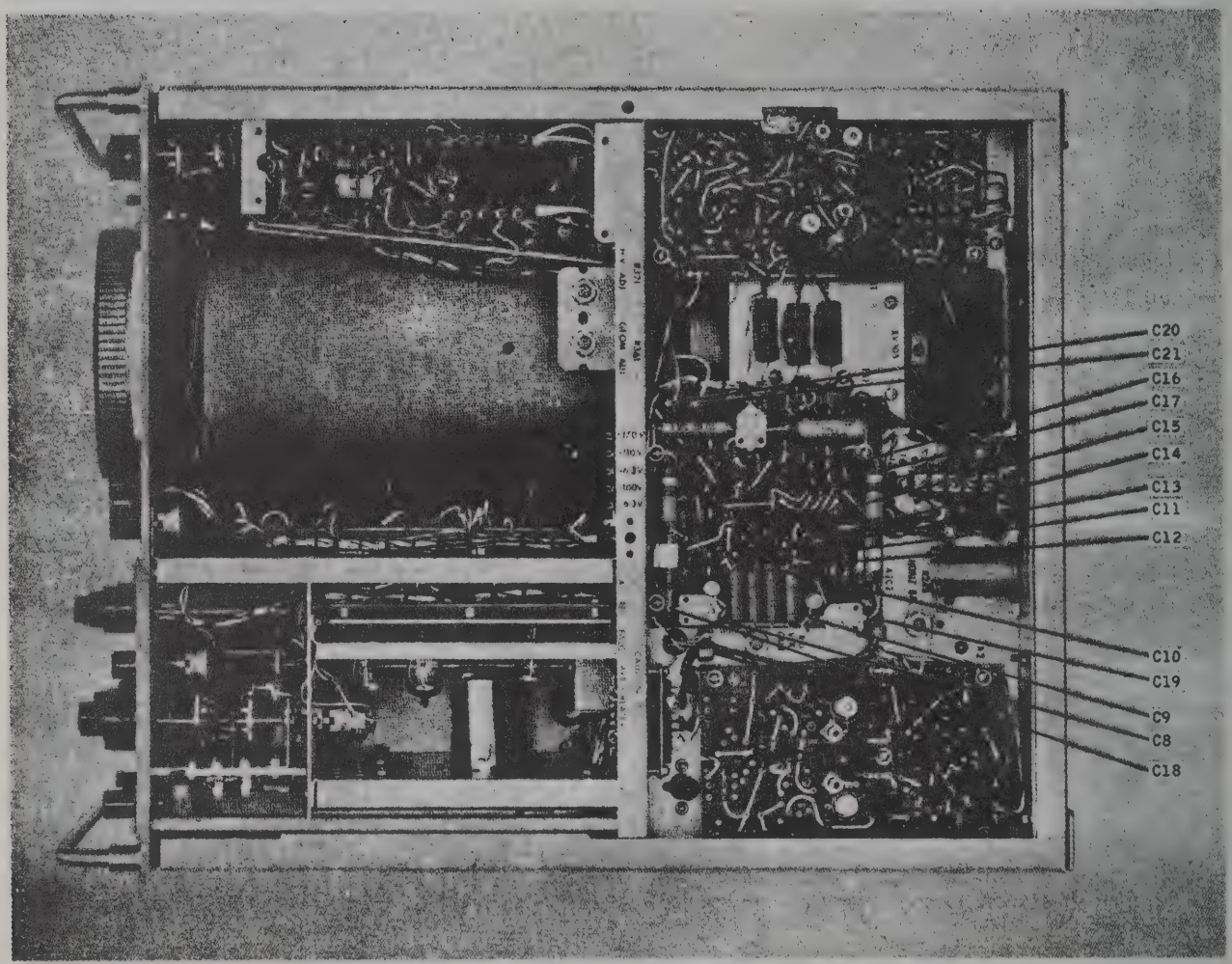


Figure 4-17. Top View, Location of Test Points on Main Horizontal Amplifier and Driver Assembly

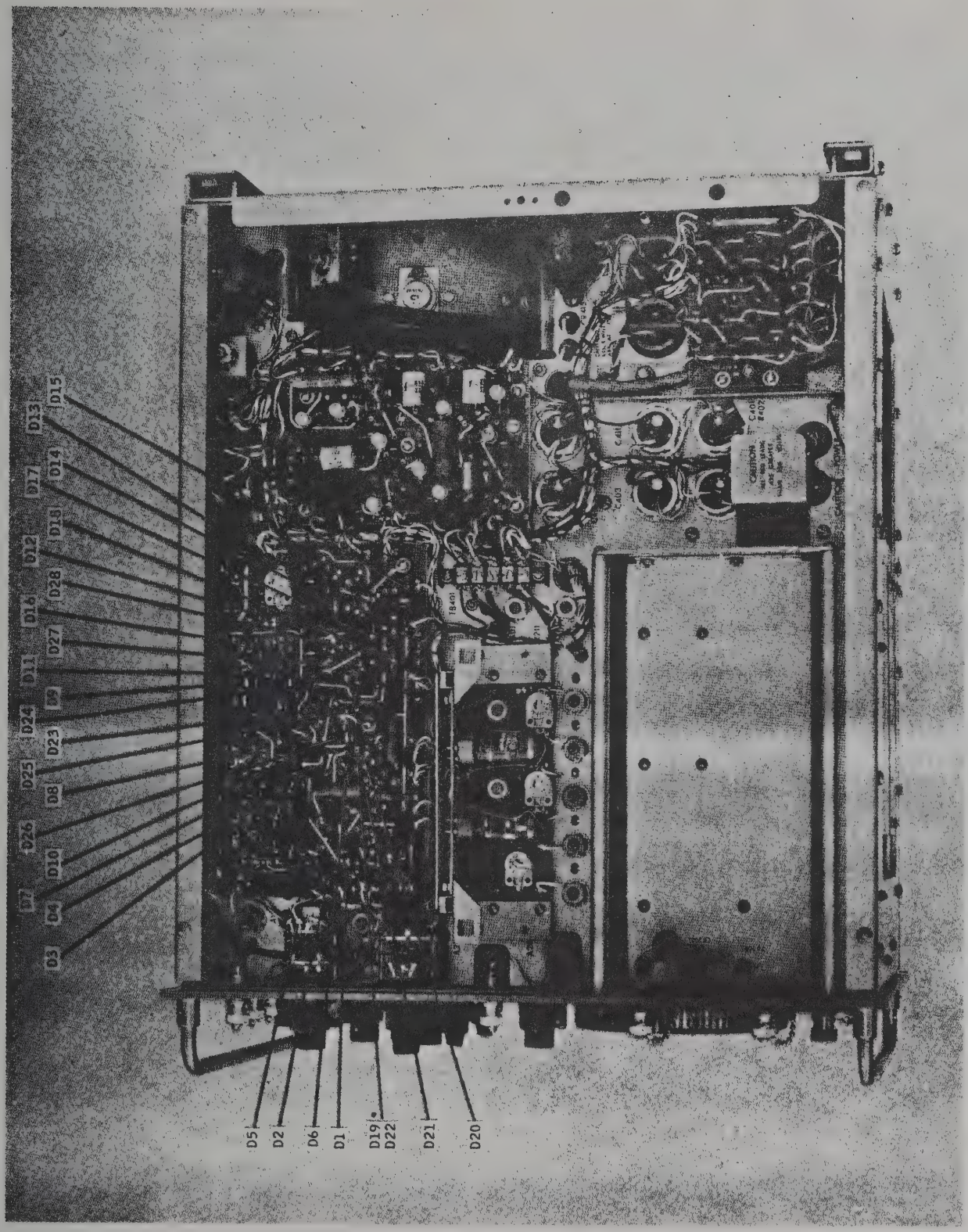


Figure 4-18. Bottom View, Location of Test Points on Sweep Generator Assembly

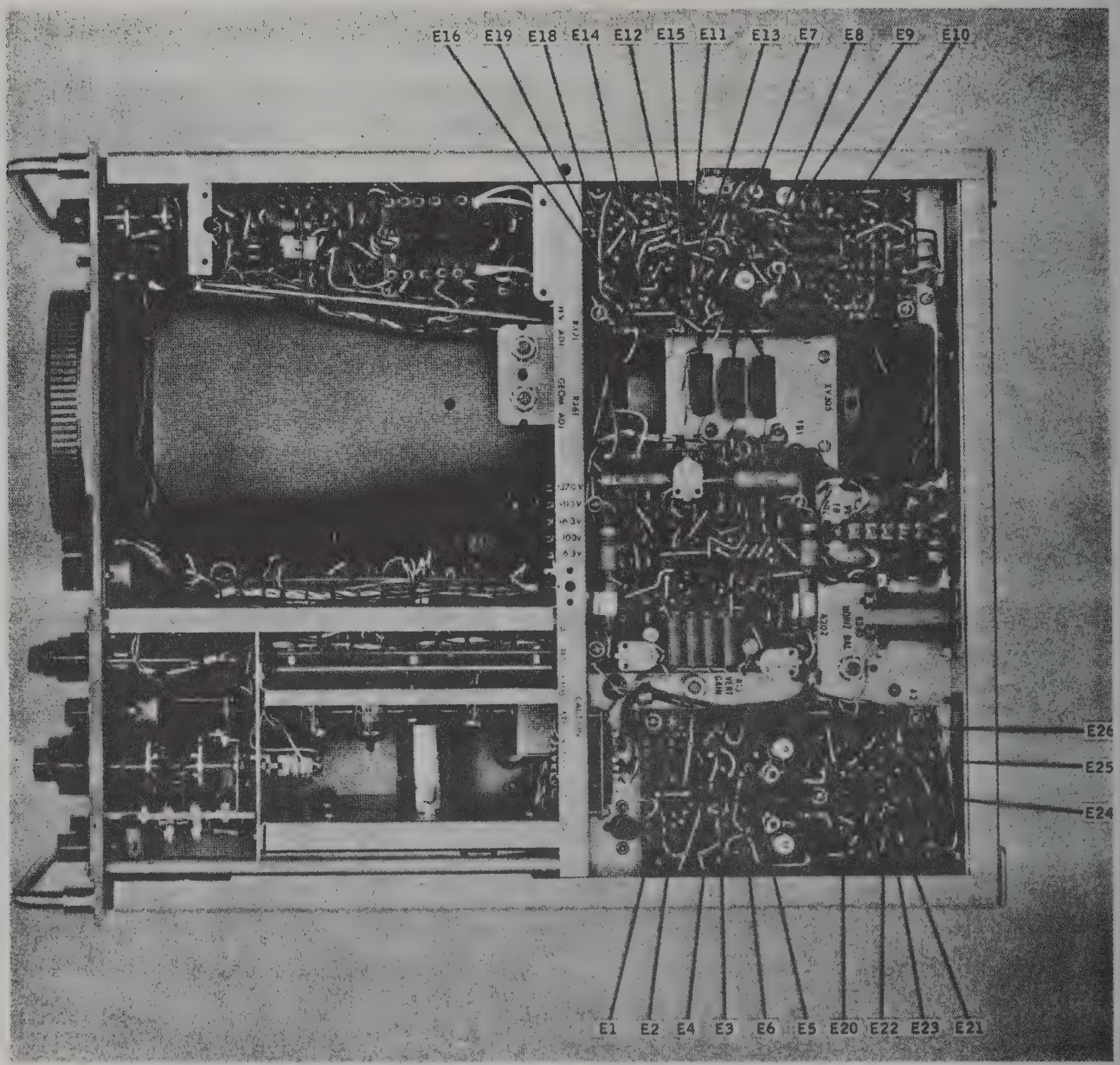


Figure 4-19. Top View, Location of Test Points on Main Vertical Amplifier Assembly

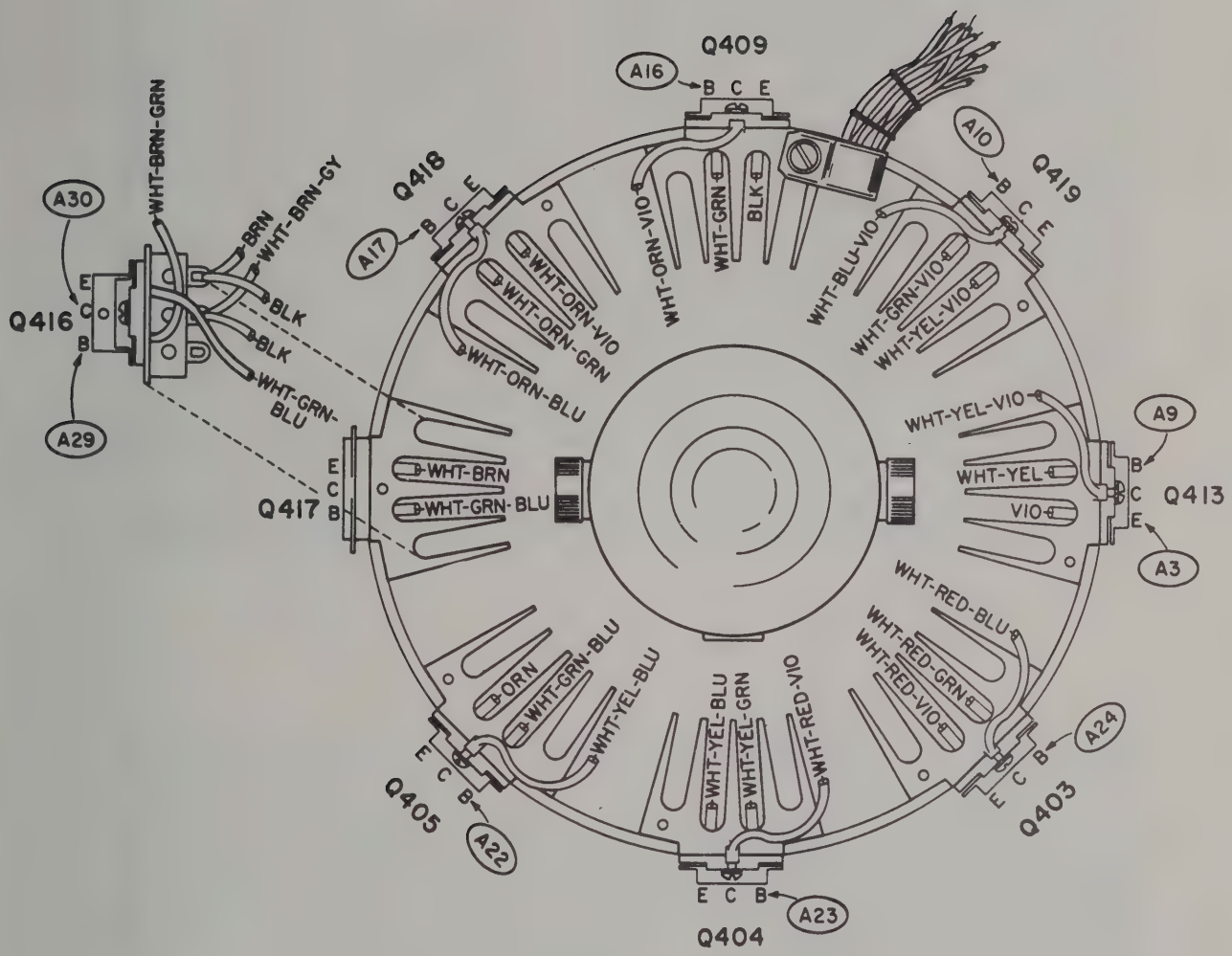


Figure 4-20. Fan Shroud and Power Transistor Assembly, Location of Test Points and Connections

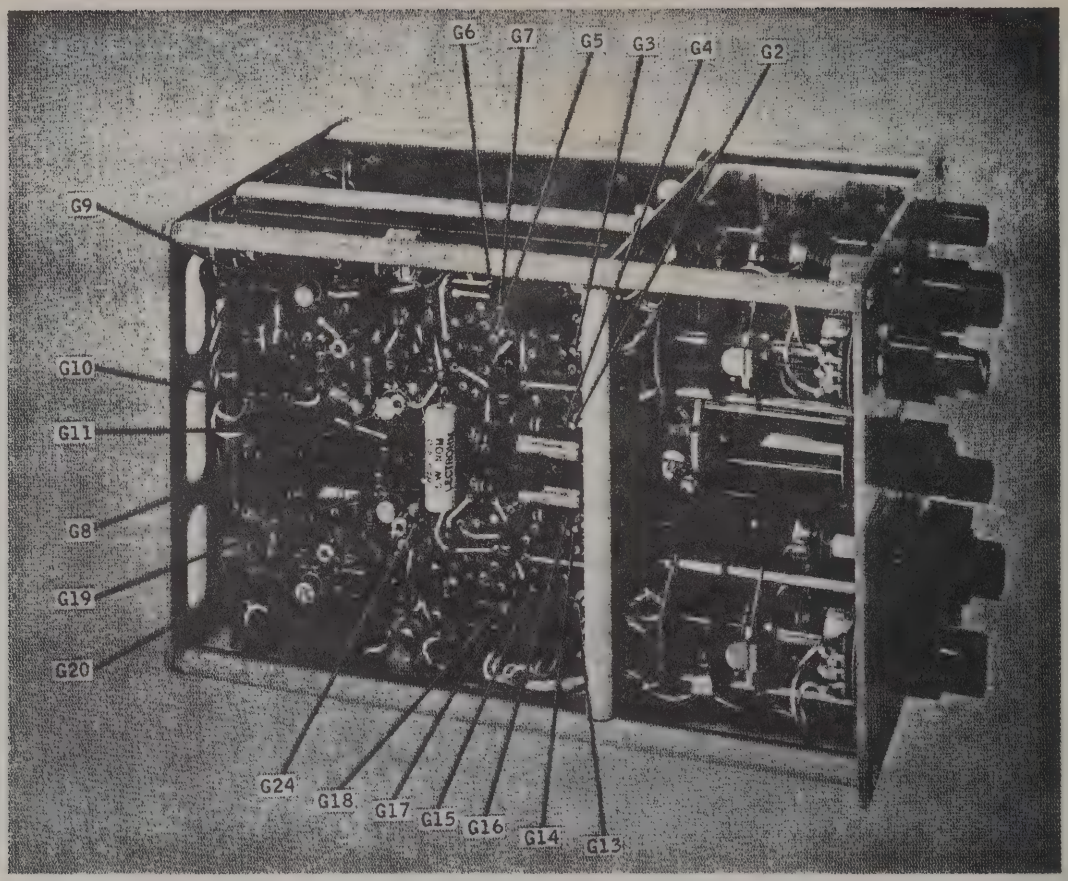


Figure 4-21. Left Side View of MX-2930B/USM Vertical Plug-In Assembly, Location of Test Points

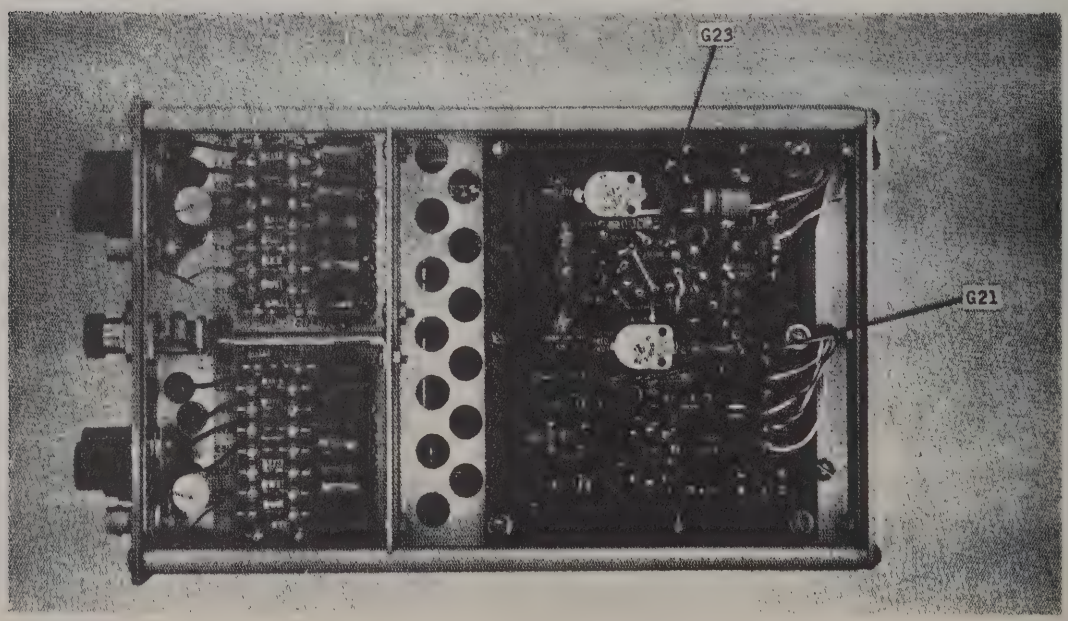


Figure 4-22. Right Side View of MX-2930B/USM, Location of Test Points

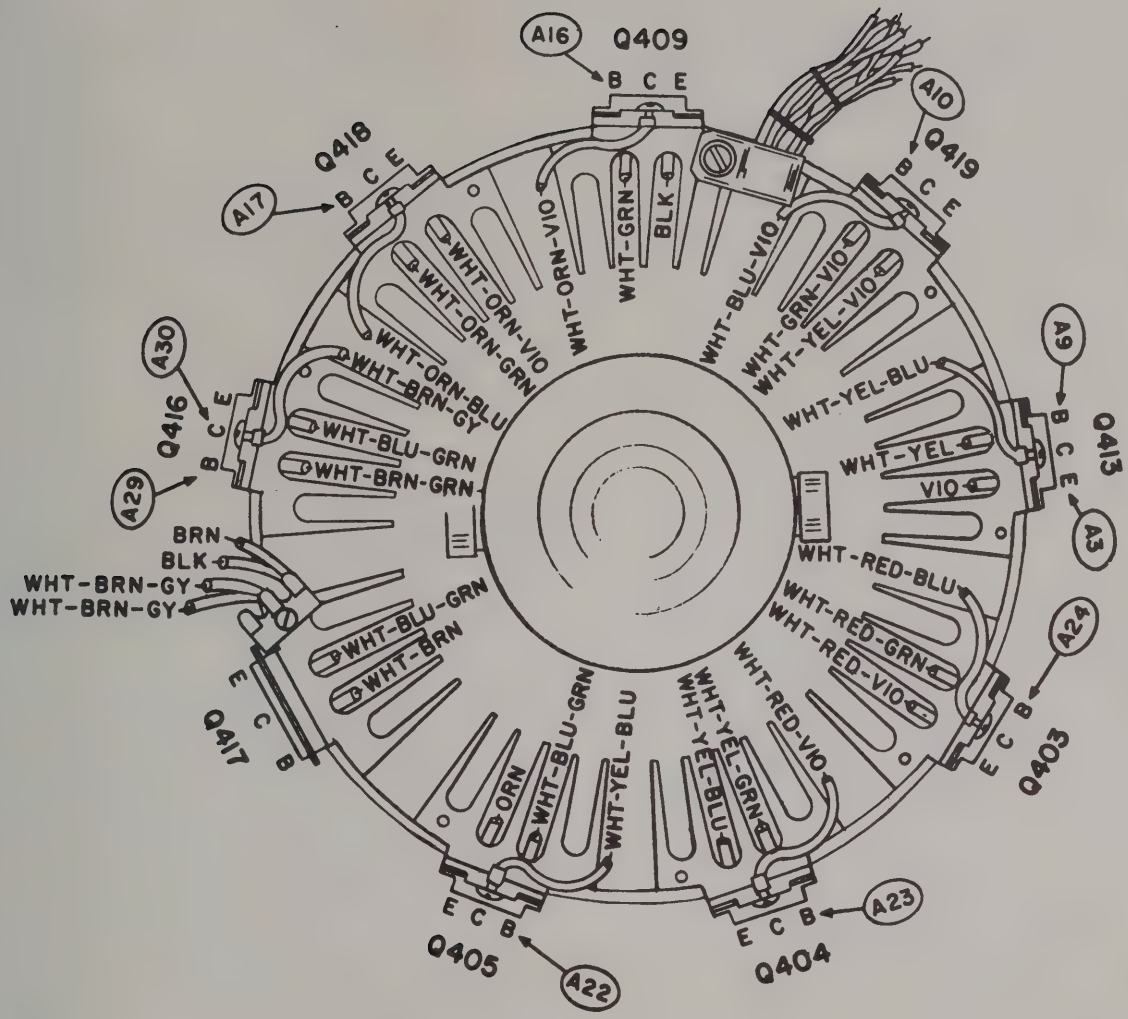


Figure 4-22a. Fan Shroud and Power Transistor Assembly, Location of Test Points and Connections for Oscilloscope AN/USM-140D

SECTION 5

MAINTENANCE

5-1. FAILURE, AND PERFORMANCE AND OPERATIONAL REPORTS.

Note

The Bureau of Ships no longer requires the submission of failure reports for all equipments. Failure Reports and Performance and Operational Reports are to be accomplished for designated equipments (refer to Electronics Installation and Maintenance Book, NAVSHIPS 900,000) only to the extent required by existing directives. All failures shall be reported for those equipments requiring the use of Failure Reports.

5-2. PREVENTIVE MAINTENANCE.

Preventive maintenance consists mainly of cleaning the air filter and checking the fan motor brushes. In addition the instrument should be given a periodic visual inspection for potential sources of trouble, which should include inspection for loose switch knobs, unseated vacuum tubes, loose or frayed wires, burned or bulging components, etc.

a. SERVICING THE AIR FILTER. — The air filter is located on the rear of the instrument cabinet. Inspect the filter bi-weekly and clean it as often as necessary. Monthly cleaning is sufficient in normal operating environments; when the instrument is used in extremely dusty environments, the filter must be cleaned more often. Proceed as follows:

(1) Remove filter by pushing it down and pulling on its top edge.

(2) Wash filter in warm water and detergent; then dry it thoroughly.

(3) Prepare and maintain a maintenance check-off list for the air filter, using the following format:

WEEK OF	AIR FILTER	
	CLEANING NOT REQUIRED	CLEANED

b. FAN MOTOR. — Every six months, add one or two drops of 10-weight machine oil to the motor bearings. The motor can be lubricated through the access hole in the right side gusset when the gusset cover plate is removed. This plate is secured by two screws. Also inspect the motor brushes and replace them when they are worn to 3/16 inch in length. Proceed as follows:

(1) Remove the cabinet for access to the fan, by resting the oscilloscope front panel down, supported by the guard rails, and removing the four retaining screws from the rear, allowing the cabinet to be lifted off.

(2) Remove the eight fan shroud screws and open the motor supporting strap.

(3) Slip the entire fan, shroud, and motor out the rear of the chassis, noting cable dress and shroud position. See figures 4-20 and 5-10. Twist slightly to give transistors clearance.

(4) Remove and inspect the brushes. Clean, replace, and dress as necessary. Brushes should be contoured to fit commutator to minimize arcing and bounce. Use air pressure to blow dust from brush holders and fan case.

(5) Add one or two drops of SAE 10 machine oil to motor bearings. Wipe off excess oil to avoid dust coating.

(6) Prepare and maintain a maintenance check-off list for the fan motor, using the following format:

MONTH	FAN MOTOR BRUSHES		BEARINGS
	REPLACEMENT NOT REQD	REPLACED	LUBRICATED

(7) To reinstall assembly, reverse the above procedure. Position the heat sink bracket (with two transistors) at 3 o'clock and position fan motor leads in notch of motor bracket.

5-3. REFERENCE STANDARDS PROCEDURES.

Note

The procedures listed below constitute the minimum number of reference standards which will indicate, when completed, the relative performance of the oscilloscope and its plug-in units. Each group of tests represents a functional section of the instrument. The procedures are listed in the suggested sequence of performance, and the power supply test must always be performed first, as indicated, to assure that all units are being supplied proper power. Otherwise, however, deviation from the listed order will in no way affect the unity or result of the reference standards.

TABLE 5-1. REFERENCE STANDARDS PROCEDURES

SECTION	ACTION REQUIRED	PROCEDURE STEPS
Power Supply (Table 5-3)	Check DC voltages	(step 1)
	AC ripple voltages	(step 2)
Calibrator (Table 5-4)	Check voltage amplitude	(step 3)
	Check voltage divider	(step 4)
Horizontal Amplifier (Table 5-5)	Check sensitivity	(steps 5 and 6)
	Check bandwidth	(step 7)
Sweep Generator (Table 5-6)	Check sweep time	(step 8)
	Check trigger sensitivity	(step 9)
Vertical Amplifier	Check sensitivity	(step 10)
	Check bandwidth	(step 11)
	Check rise time	(step 12)
MX-2930B/USM Vertical Plug-In	Check vertical sensitivity	(steps 13 and 14)
	Check vertical pulse response	(step 15)
	Check vertical bandwidth	(step 16)
	Check isolation	(step 17)
	Check common mode rejection	(step 18)
	Check chopped display	(step 19)
	Check alternate display	(step 20)

Test equipment required to complete the Reference Standards Procedures is listed in table 5-2. Figure 5-1 shows the test connector that must be fabricated to allow test of the main vertical amplifier with the vertical channel plug-in unit removed.

TABLE 5-2. TEST EQUIPMENT FOR REFERENCE STANDARDS PROCEDURES

DESIGNATION	NAME
Model 738A	Voltmeter Calibrator (Hewlett-Packard)
AN/USM-108	Time-Mark Generator
Model 107	Square Wave Generator (Tektronix)
Model 190A	Constant-Amplitude Signal Generator (Tektronix)
AN/USM-98	Voltmeter
ME-6/U	AC Voltmeter

NOTE: See table 1-2 for full description.

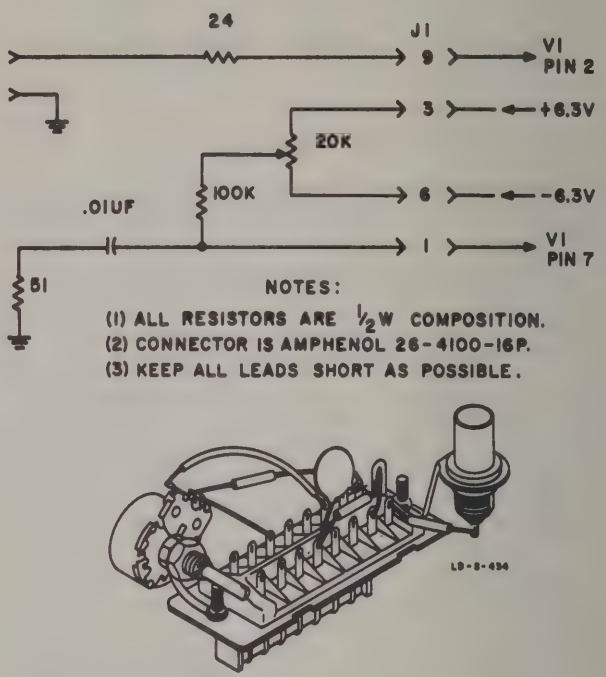
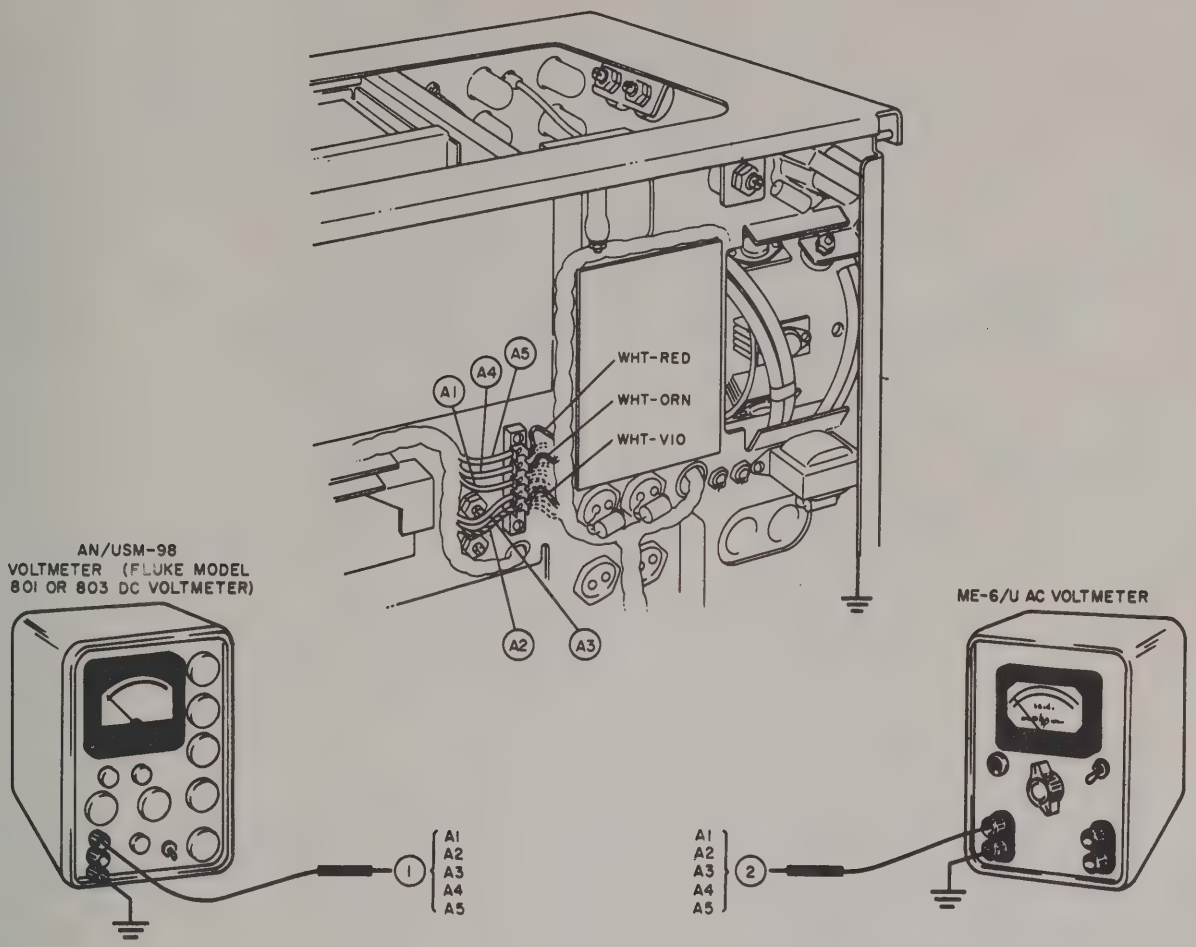


Figure 5-1. Main Vertical Amplifier Test Connector

TABLE 5-3. POWER SUPPLY



Control Settings:

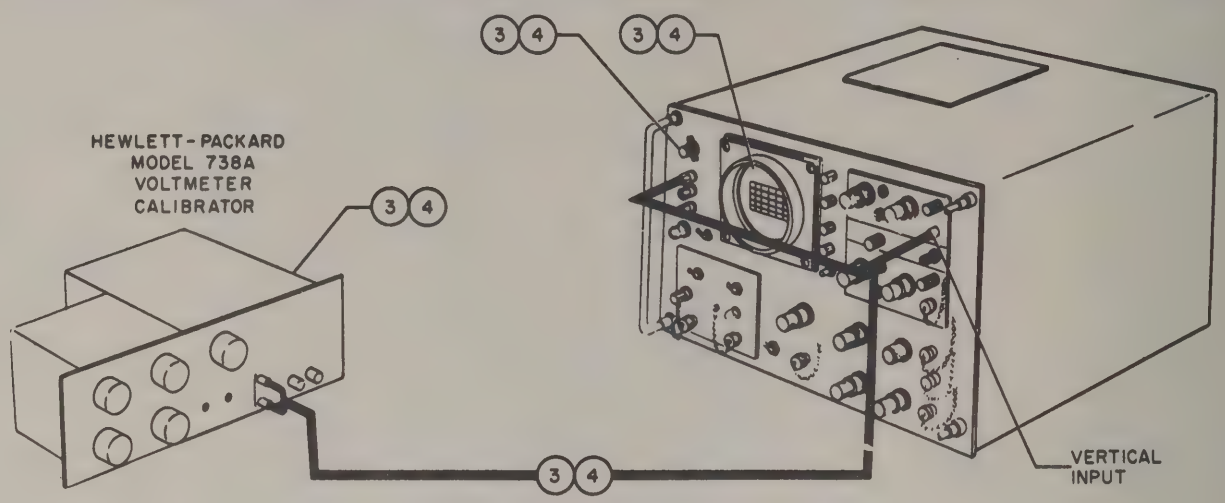
Power on
Chassis Grounded

Test Equipment Required:

AN/USM-98 Voltmeter
ME-6/U AC Voltmeter

STEP NO.	ACTION REQUIRED	READ INDICATION ON	PERFORMANCE STANDARDS
1	Check DC voltages	AN/USM-98 Voltmeter	A1 +6.3 volts ±1 volt A2 -6.3 volts ±1 volt A3 -100 volts ±0.4% A4 +110 volts ±0.4% A5 +370 volts ±1%
	PROCEDURE: Remove the Oscilloscope from the cabinet (see paragraph 5-2b) and ground the chassis. Turn the instrument ON and allow a few minutes warmup. Ground an AN/USM-98 Voltmeter to the chassis and measure the voltages at the test points shown in table 5-3.		
2	Check AC ripple voltage	ME-6/U AC Voltmeter	A1 7 MVAC A2 7 MVAC A3 3 MVAC A4 7 MVAC A5 18 MVAC
	PROCEDURE: Disconnect the AN/USM-98 Voltmeter and ground a ME-6/U AC Voltmeter to the chassis. Measure the ripple voltages at the test points shown in table 5-3. The AC ripple should be as listed at the right. These voltages are greater than the typical voltages listed on the schematic and are the maximum allowable.		

TABLE 5-4. CALIBRATOR



Control Settings:

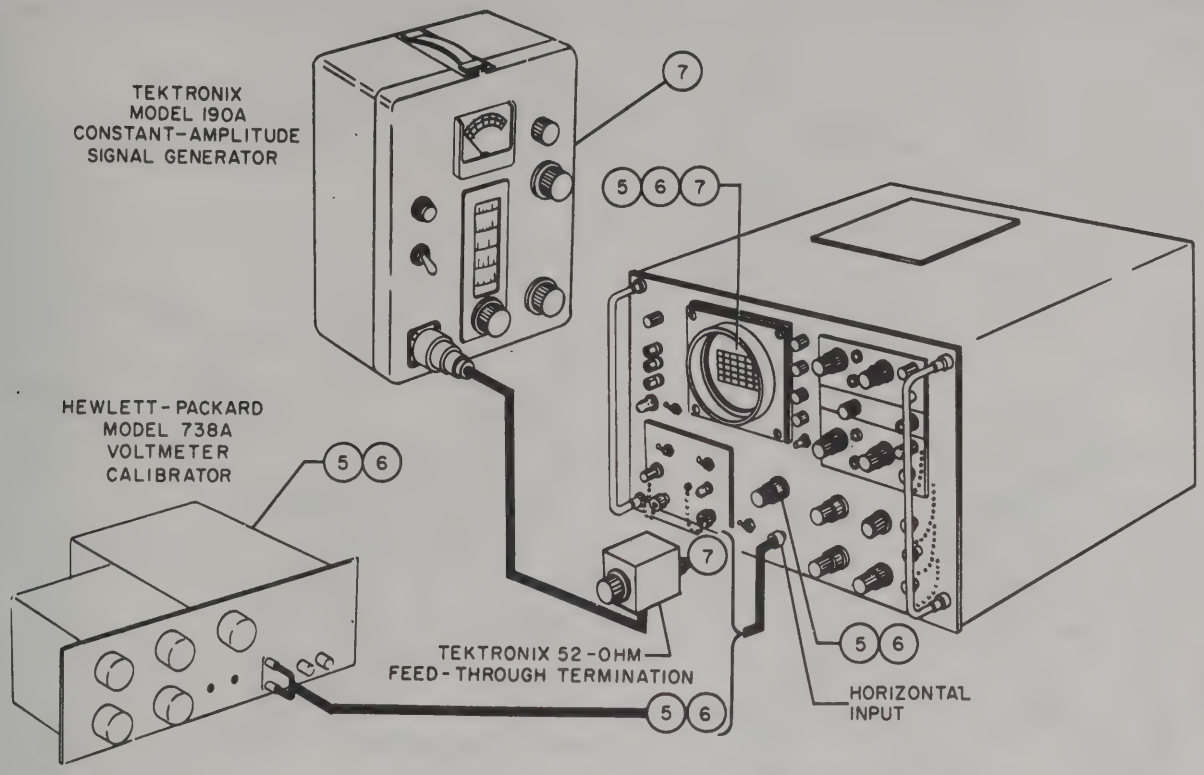
HORIZONTAL DISPLAY to X1
TRIGGER SOURCE to INT
SWEEP MODE to PRESET
SWEEP TIME to 2 MILLISECONDS/CM
VERTICAL SENSITIVITY to 2 VOLTS/CM
CALIBRATOR to OFF

Test Equipment Required:

Hewlett-Packard Model 738A
Voltmeter Calibrator

STEP NO.	ACTION REQUIRED	READ INDICATION ON	PERFORMANCE STANDARDS
3	Check amplitude of CALIBRATOR voltage	Oscilloscope	The amplitudes of the square wave and sine wave should not differ by more than 3%
	PROCEDURE: Set the Voltmeter Calibrator for a 10-volt, 400-cycle peak-to-peak output, and connect this signal to the vertical INPUT. Note the exact amplitude of the sine wave on the CRT. Disconnect the Voltmeter Calibrator, set the CALIBRATOR control at 10-volt output, and connect the CALIBRATOR output at VOLTS to the vertical INPUT. Note the exact amplitude of the square wave.		
4	Check CALIBRATOR voltage divider	Oscilloscope	Same as above
	PROCEDURE: Check all the CALIBRATOR voltage ranges by comparing equal voltages from the CALIBRATOR output and from the Voltmeter Calibrator. Use the same procedure as above.		

TABLE 5-5. HORIZONTAL AMPLIFIER



Control Settings:

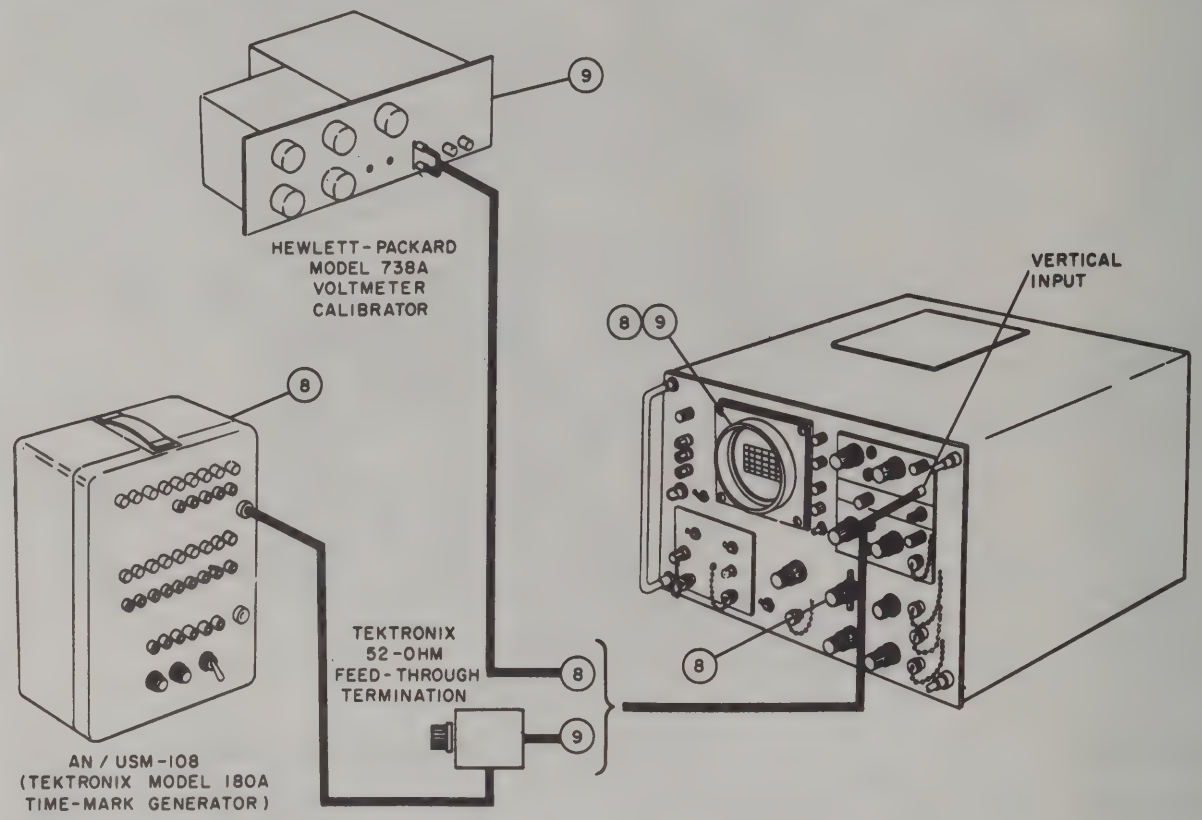
AC-DC SWITCH to AC
EXTERNAL VERNIER to CAL

Test Equipment Required:

Hewlett-Packard Model 738A
Voltmeter Calibrator
Tektronix Model 190A Constant-Amplitude
Signal Generator

STEP NO.	ACTION REQUIRED	READ INDICATION ON	PERFORMANCE STANDARDS
5	Check horizontal sensitivity	Oscilloscope	A. Trace extends 10 ±0.3 cm B. Trace extends 5 ±0.15 cm
	PROCEDURE: Connect 1 volt peak-to-peak from Voltmeter Calibrator to horizontal INPUT. Adjust position controls to center horizontal trace. A. Set HORIZONTAL DISPLAY to .1 VOLTS/CM B. Set HORIZONTAL DISPLAY to .2 VOLTS/CM		
6	Check horizontal sensitivity range	Oscilloscope	A. Trace extends 10 ±0.3 cm B. Trace extends 5 ±0.15 cm
	PROCEDURE: With the test set-up as in step 13, increase the voltages from the Voltmeter Calibrator to 10 times the voltage shown on the HORIZONTAL DISPLAY switch. The CRT should show trace A. When the HORIZONTAL DISPLAY switch is moved to the next higher setting, the CRT should show trace B. Repeat this procedure in sequence for the entire range of the HORIZONTAL DISPLAY switch.		
7	Check horizontal bandwidth	Oscilloscope	The frequency at which the deflection on the CRT decreased to 7.1 cm (3 db point) should be greater than 1 mc.
	PROCEDURE: Reset HORIZONTAL DISPLAY to .1 VOLTS/CM and disconnect the Voltmeter Calibrator. Center spot with the positioning controls and BEAM FINDER if necessary. Connect 50-kc output from Signal Generator to the horizontal INPUT of the Oscilloscope. Adjust 50-kc amplitude for 10-cm deflection on the CRT. Increase the frequency from the Signal Generator and note the deflection on CRT.		

TABLE 5-6. SWEEP GENERATOR



Control Settings:

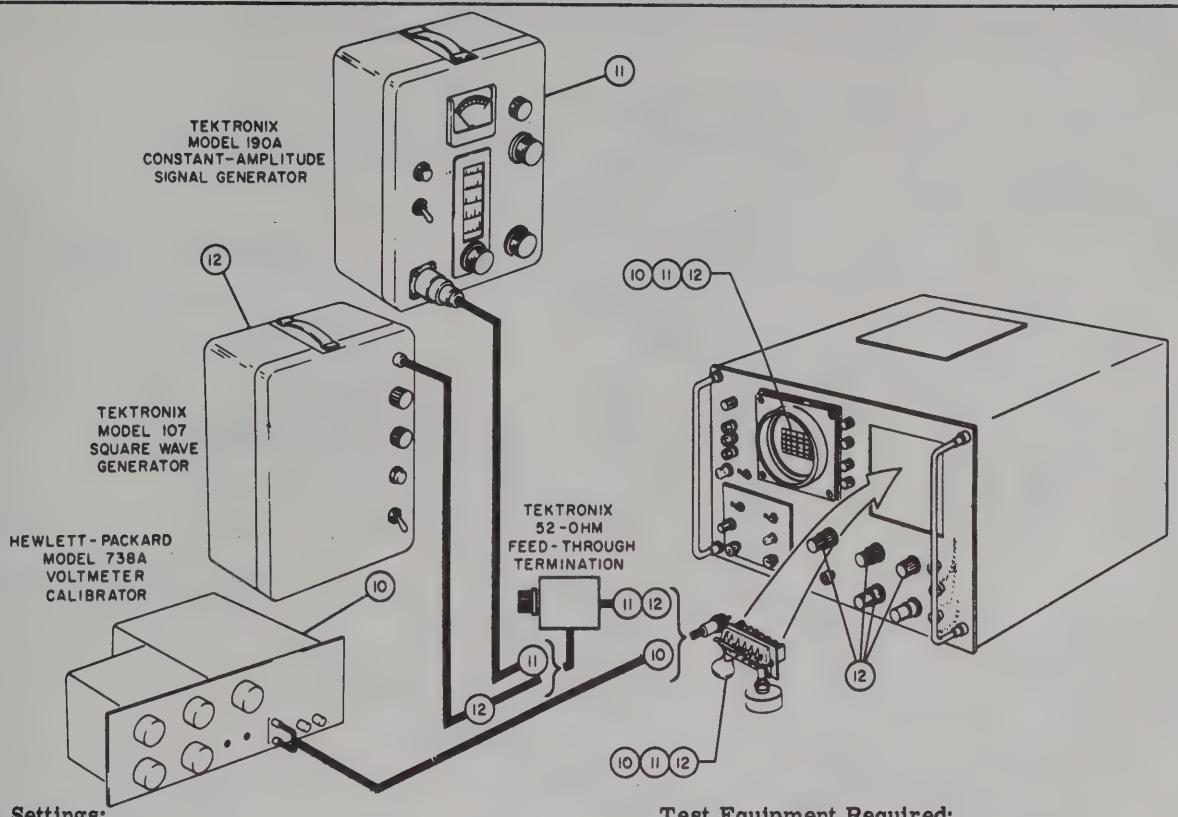
HORIZONTAL DISPLAY to X1
TRIGGER SOURCE to INT
SWEEP MODE to TRIGGER
SWEEP TIME to 1 MICROSECOND/CM
Adjust VERTICAL SENSITIVITY for 1-CM Deflection

Test Equipment Required:

AN/USM-108 Time-Mark Generator
Hewlett-Packard Model 738A Voltmeter Calibrator

STEP NO.	ACTION REQUIRED	READ INDICATION ON	PERFORMANCE STANDARDS
8	Check sweep time	Oscilloscope	1 marker per 1 cm ±3% in each case
	PROCEDURE: Connect 1-μsec time marks from Time-Mark Generator to vertical INPUT, check that the SWEEP TIME control is 1 MICROSECOND/CM, and note the CRT display. Change the SWEEP TIME control to 1 MILLISECOND/CM and then to 1 SECOND/CM and simultaneously set the Time-Mark Generator to produce the corresponding time markers (i.e., 1 millisecond markers and 1 second markers).		
9	Check sweep trigger sensitivity	Oscilloscope	Sweep triggered without jitter
	PROCEDURE: Disconnect the Time-Mark Generator. Change the VERTICAL SENSITIVITY control to 1 VOLT/CM, the VERNIER to CALIBRATED, the SWEEP TIME to 1 MILLISECOND/CM, SWEEP MODE to PRESET, and TRIGGER LEVEL to 0. Connect a 0.2-volt peak-to-peak signal from the Voltmeter Calibrator to the vertical INPUT.		

TABLE 5-7. MAIN VERTICAL AMPLIFIER



Control Settings:

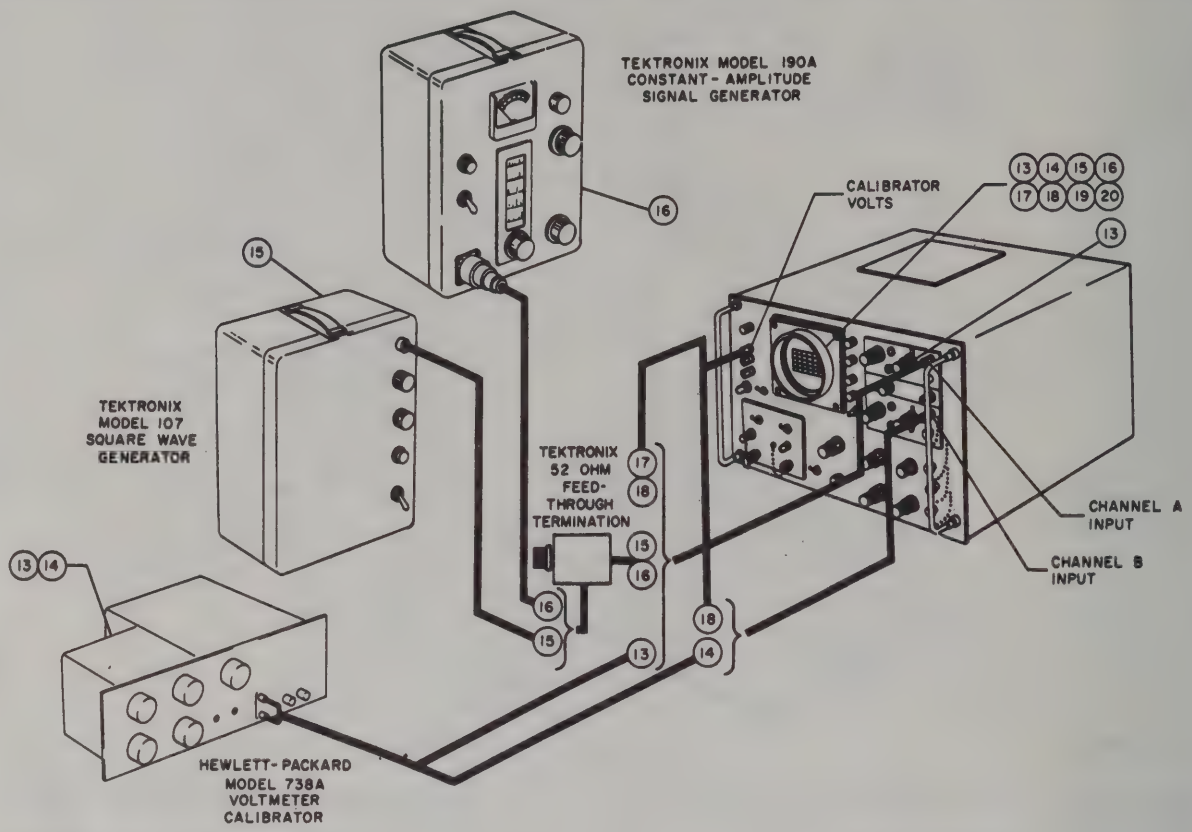
Remove Vertical Plug-In and Insert Test Connector (See Figure 5-1)
HORIZONTAL DISPLAY to X1
SWEEP TIME to 2 MILLISECONDS/CM
TRIGGER SOURCE to INT
SWEEP MODE to PRESET
TRIGGER LEVEL to 0

Test Equipment Required:

Hewlett-Packard Model 738A Voltmeter Calibrator
Tektronix Model 190A Constant-Amplitude Signal Generator
Tektronix Model 107 Square Wave Generator

STEP NO.	ACTION REQUIRED	READ INDICATION ON	PERFORMANCE STANDARDS
10	Check Main Vertical Amplifier sensitivity	Oscilloscope	Peak-to-peak deflection of 4 ±0.2 cm
	PROCEDURE: Connect a 400-cps, 0.8-volt peak-to-peak signal from the Voltmeter Calibrator to the Main Vertical Amplifier through the test connector.		
11	Check Main Vertical Amplifier bandwidth	Oscilloscope	Frequency at which deflection on CRT decreases to 2.8 cm (3 db point) should be greater than 30 mc (typically above 35)
	PROCEDURE: Connect the 50-kc output from the Signal Generator to the Main Vertical Amplifier through the test connector. Adjust the 50-kc amplitude for a 4-cm deflection on the CRT. Increase the frequency from the Signal Generator and note the deflection on the CRT.		
12	Check Main Vertical Amplifier rise time	Oscilloscope	Rise time (10-90%): 11 msec (0.55 cm) or less
	PROCEDURE: Set the HORIZONTAL DISPLAY to X5, SWEEP TIME to .1 MICROSECOND/CM, and TRIGGER LEVEL to +. Connect a 1-mc, 0.5-volt square wave from the Square Wave Generator to the Main Vertical Amplifier through the test connector. Center the leading edge of the square wave with the control on the test connector and the HORIZONTAL POSITION control. Adjust the TRIGGER LEVEL to shift the leading edge of the square wave as far to the right as possible.		

TABLE 5-8. MX-2930B/USM VERTICAL PLUG-IN


TEKTRONIX MODEL 190A CONSTANT-AMPLITUDE SIGNAL GENERATOR
CALIBRATOR VOLTS
TEKTRONIX MODEL 107 SQUARE WAVE GENERATOR
TEKTRONIX 52 OHM FEED-THROUGH TERMINATION
CHANNEL A INPUT
CHANNEL B INPUT
HEWLETT-PACKARD MODEL 738A VOLTMETER CALIBRATOR

Control Settings:

CHANNEL A + B VERNIER to CAL
AC-DC SWITCH to AC
Vertical Presentation Switch to CHANNEL A
SWEEP MODE to PRESET
SWEEP TIME to 5 MILLISECONDS/CM
SENSITIVITY CONTROL VERNIER to CALIBRATED
TRIGGER SOURCE to INT

Test Equipment Required:

Hewlett-Packard Model 738A Voltmeter Calibrator
Tektronix Model 107 Square Wave Generator
Tektronix Model 190A Constant-Amplitude Signal Generator

STEP NO.	ACTION REQUIRED	READ INDICATION ON	PERFORMANCE STANDARDS
13	Check Channel A vertical sensitivity	Oscilloscope	A. 5 ±0.25 cm (±5%) deflection
	PROCEDURE Set the Voltmeter Calibrator to 400-cycle 0.1-volt peak-to-peak output and couple this signal to the Channel A INPUT. Set the SENSITIVITY control to .02 VOLTS/CM. CRT deflection should be as in A. Repeat this check at each position of the SENSITIVITY control. Set the Voltmeter Calibrator output as necessary to provide adequate deflection on the CRT. Performance should be as in B.		B. Deflection should be $\left[\frac{\text{output voltage}}{\text{SENSITIVITY}} = \text{cm}\right]$ with a tolerance of 5% in each case
14	Check Channel B vertical sensitivity	Oscilloscope	Same as above
	PROCEDURE: Same as above, except Vertical Presentation Switch to CHANNEL B and Voltmeter Calibrator to Channel B INPUT.		

TABLE 5-8. (Continued)

STEP NO.	ACTION REQUIRED	READ INDICATION ON	PERFORMANCE STANDARDS
15	Check vertical pulse response	Oscilloscope	Overshoot on leading edge of applied signal must not exceed 1%
	PROCEDURE: Change SWEEP TIME control to 0.2 MICROSECOND/CM and Channel A SENSITIVITY to 0.02 VOLTS/CM. Set the Square Wave Generator to produce a 0.25-volt AC peak-to-peak 500-kc signal and couple this to the Channel A INPUT. Change the Vertical Presentation Switch back to CHANNEL A.		
16	Check vertical bandwidth	Oscilloscope	The frequency must be at least 22 mc when the deflection is 2.8 cm
	PROCEDURE: Set the SENSITIVITY control to 1 VOLT/CM, the HORIZONTAL DISPLAY switch to X1, and connect a 50-kc sine wave from a Constant-Amplitude Signal Generator to the Channel A INPUT. Adjust the input signal level for a CRT deflection of exactly 4 centimeters. Without changing the signal level, increase the signal frequency until the height of the display is reduced to 2.8 centimeters.		
17	Isolation check	Oscilloscope	The height of CRT display should not exceed 0.3 cm
	PROCEDURE: Disconnect the Square Wave Generator. Change the Vertical Presentation switch to CHANNEL B, the SENSITIVITY control to 0.5 VOLT/CM on Channel A and .02 VOLT/CM on Channel B, the HORIZONTAL DISPLAY to X1, the SWEEP TIME control to 1 MILLISECOND/CM, and center the display with the VERTICAL POSITION control. Apply a 20-volt square wave to Channel A INPUT from the CALIBRATOR output. After noting the deflection, check the reverse coupling by reversing the settings and connection of Channels A and B and their controls.		
18	Common mode rejection check	Oscilloscope	A&B SENSITIVITY / Input Voltage / Deflection (cm): .02 / 2 / 1; .05 / 5 / 3; .10 / 10 / 3; .20 / 20 / 3; .50 / 50 / 3; 1 / 100 / 3; 2 / 100 / 1.5; 5 / 100 / 0.6; 10 / 100 / 0.3; 20 / 100 / 0.15
	PROCEDURE: Connect the output of the CALIBRATOR to Channel A and B INPUTS in parallel (through a T-connector). Change the Vertical Presentation Switch to A-B, the AC-DC switch to DC, and keep the HORIZONTAL DISPLAY switch at X1. Measure the common mode rejection on all SENSITIVITY ranges and note that the deflections correspond to the table at the right.		
19	Chopped display check	Oscilloscope	The chopped period should be between 0.9 and 1.1 microsecond. The transition between the chopped traces should be blanked out at normal intensity levels
	PROCEDURE: Remove all connections from the INPUT jacks. Set the Vertical Presentation Switch to CHOPPED, the SWEEP TIME control to .5 MICROSECOND/CM, and adjust the VERTICAL POSITION control for two distinct chopped traces. There should be no signal at any input to the Oscilloscope.		
20	Check on alternate display	Oscilloscope	The display should show two distinct traces throughout the sweep range
	PROCEDURE: With the Oscilloscope setup as in step 19, change the Vertical Presentation Switch to the ALTERNATE position. Vary the SWEEP TIME from 20 MILLISECONDS/CM to 0.1 MICROSECONDS/CM.		

5-4. ADJUSTMENTS.

The procedures below give instructions for complete calibration to insure optimum equipment performance. However, complete calibration is seldom required, and the adjustment for any one particular section can be performed separately if the other sections are known to be calibrated and operating correctly. Table 3-4 lists the adjustments required following replacement of individual tubes, diodes, and transistors. Whether complete or partial calibration is to be done, make the adjustments in the sequence in which they are given below, since the adjustments on one section may influence the performance of another section. For cabinet removal procedure, see paragraph 5-2b.

Test equipment and special tools required to complete the adjustments are listed in table 5-9. Equipment with similar specifications can be substituted for that listed. The special vertical test connector shown in figure 5-1 is required to apply signals directly to the main vertical amplifier. The connector makes the frequency response adjustment in the main vertical amplifier independent of the plug-in units.

a. LOW-VOLTAGE POWER SUPPLY ADJUSTMENT. — Location of adjustments in the low-voltage supply is shown in figure 5-2. Test points are shown in table 5-3 and figure 4-14.

CAUTION

Never allow any power supply voltage to short directly to ground or to another circuit. Such a short will destroy the power supply transistors instantaneously.

(1) -100 VOLT SUPPLY. Adjust -100V Adj, R452, for exactly -100 volts at test point A3 (white-violet).

(2) ±6.3 VOLT SUPPLY.

(a) Adjust 6.3V Adj, R464, for +6.3 volts at test point A1 (brown wire).

(b) Check for -6.3 volts ±0.1 volt at test point A2 (white-brown wire). Any unbalance is due to unbalance in tube heaters. If the unbalance is excessive, it can be remedied by changing vacuum tubes.

(3) +110 VOLT SUPPLY. Adjust +110V Adj, R431, for exactly +110 volts at test point A4 (white-orange wire).

(4) +370 VOLT SUPPLY. Adjust +370V Adj, R411, for +370 volts at test point A5 (white-red wire).

b. HIGH-VOLTAGE POWER SUPPLY ADJUSTMENT. — Location of the adjustment for the -1500-volt high-voltage power supply is shown in figure 5-3. Test points are shown in figure 4-15.

WARNING

Dangerous voltages will be encountered in the following procedure. Use extreme caution and follow the directions exactly.

(1) Remove the shield from the high-voltage power supply which is accessible through the left-side gusset.

(2) Turn on the oscilloscope and allow a 5-minute warm-up period.

(3) Connect the high-voltage voltmeter (AN/USM-116) between ground and test point B1 (yellow wire connected to V310 plate cap). The voltmeter should indicate -1500 volts. If not, recheck the oscilloscope low-voltage power supply before continuing.

(4) If necessary, adjust R321 to produce exactly -1500 volts. After making this adjustment, it will be necessary to recheck horizontal and vertical gains, frequency response, and sweep times.

TABLE 5-9. TEST EQUIPMENT FOR ADJUSTMENT PROCEDURES

DESIGNATION	NAME
AN/USM-98	Voltmeter
AN/USM-116	High-Voltage Voltmeter
Model 738A	Voltmeter Calibrator (Hewlett-Packard)
Model 107	Square Wave Generator (Tektronix)
AN/USM-108	Time-Mark Generator
AN/URM-90	Q Meter

NOTE: See table 1-2 for full description.

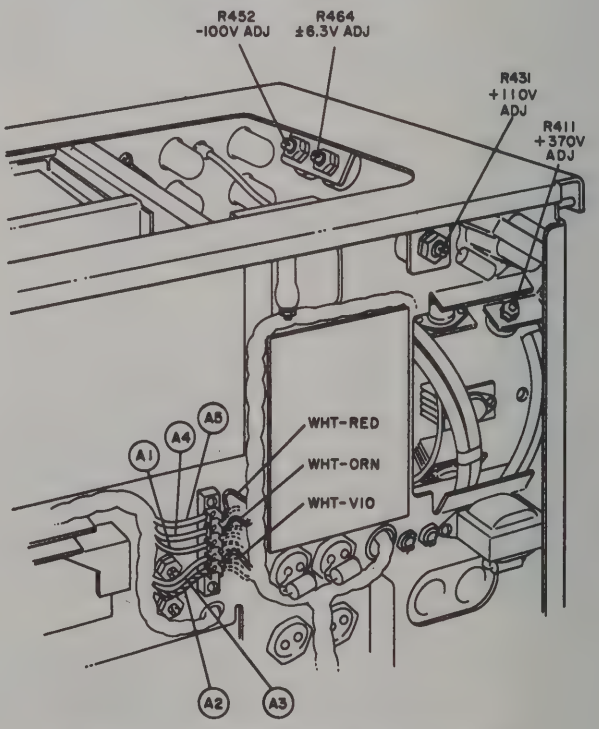


Figure 5-2. Location of Low-Voltage Power Supply Adjustments

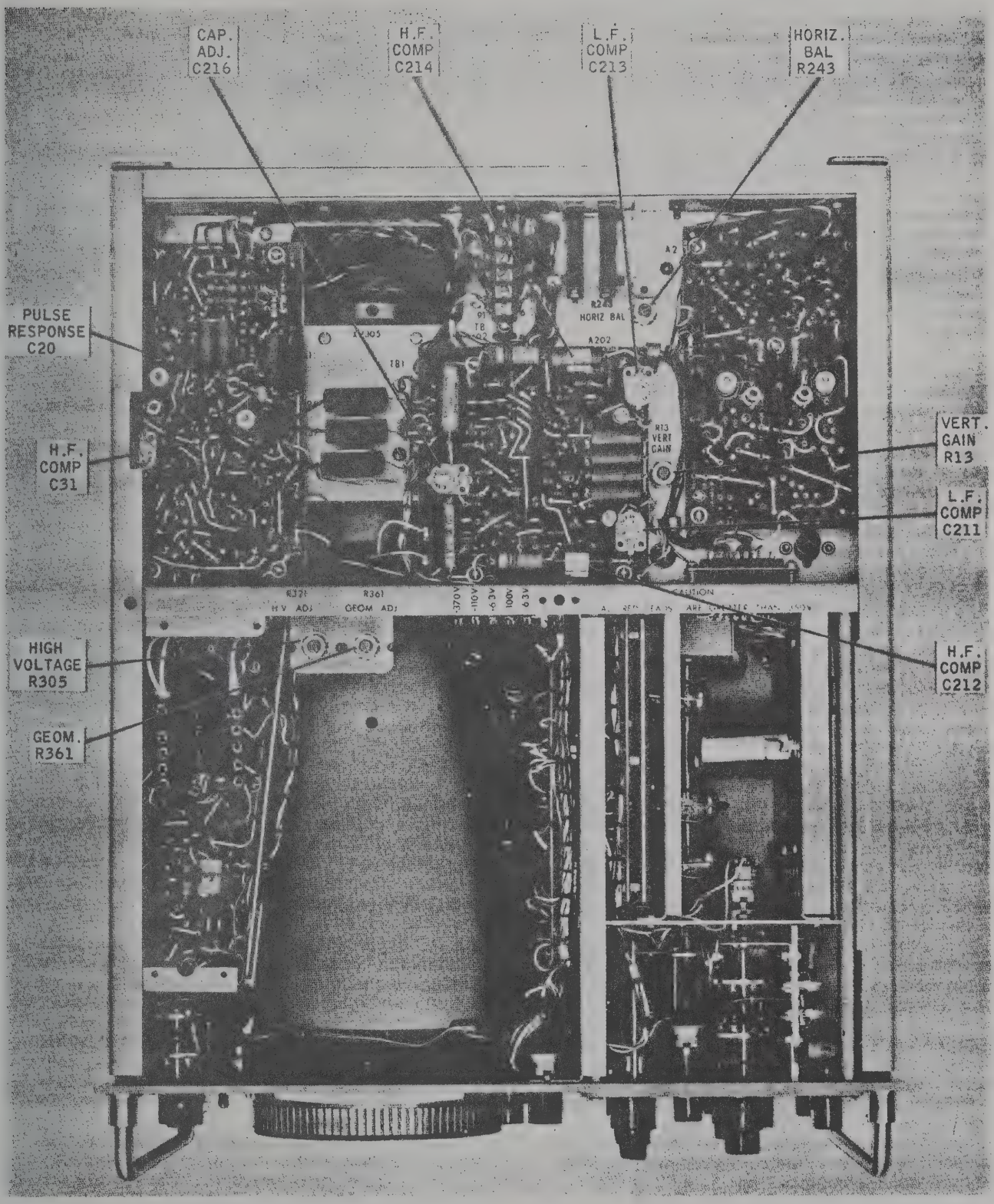


Figure 5-3. Top View, Location of Adjustments

c. GEOMETRY ADJUSTMENT. — The geometry adjustment control (R361) sets the voltage applied to the CRT grid (pin 4) for minimum deflection distortion at the edges of the graticule. Before making any adjustments, check that the graticule is properly aligned with the CRT.

(1) With the MX-2930B/USM Vertical Plug-In installed, apply a signal from the amplitude CALIBRATOR to the vertical INPUT. Set the SWEEP MODE control just out of PRESET and position the vertical trace (4-cm high) parallel and next to the left edge of the graticule. Note any nonlinearity and reposition the display at the right edge of the graticule. Again note any nonlinearity in the display. Remove all vertical input signals, and set the SWEEP MODE control to FREE RUN. Position the trace (10-cm long) alternately at the top and the bottom of the graticule, noting in each case any deviations from a straight line trace as compared to the graticule edge.

(2) If there is any distortion in the vertical or horizontal traces, change the adjustment of the Geometry control, R361, to correct this. The trace should be moved from one end to the opposite end of the graticule both horizontally and vertically to compare the effects of any adjustments. See figure 5-3 for location of R361.

d. HORIZONTAL AMPLIFIER ADJUSTMENT. — The location of test points and adjustments for the horizontal amplifier are shown in figures 4-16, 4-17, and 5-24. For parts location refer to figure 5-23.

(1) BALANCE. —

(a) Remove oscilloscope cabinet, turn the instrument on and allow a 5-minute warmup.

(b) Set the HORIZONTAL DISPLAY control midway between the INTERNAL SWEEP X1 and the .1 VOLT/CM positions.

(c) Adjust the Balance control R243 (see figure 5-3) to center position the spot in the center of the CRT graticule.

(d) Set the HORIZONTAL DISPLAY control to .1 VOLTS/CM.

(e) Adjust the Vern. Bal. control R211 (see figure 5-4) until the spot remains horizontally stationary as the EXTERNAL VERNIER control is rotated over its full range. If necessary, adjust the HORIZONTAL POSITION control to keep spot approximately centered.

(2) SENSITIVITY. —

(a) With the instrument off, unsolder the yellow wire on the edge of the etched circuit board A101 (see figure 5-10).

(b) Set the HORIZONTAL DISPLAY control to INTERNAL SWEEP X1, and center spot with the HORIZONTAL POSITION control.

(c) Connect a 50-volt peak-to-peak sine wave from a Model 738 Voltmeter Calibrator to the etched circuit board A101 at the point from which the yellow wire was removed.

(d) Turn instrument on, allow a few minutes to warm up, and adjust Sweep Gain, R202 for 5.5-centimeters of deflection.

(e) Set the HORIZONTAL DISPLAY control to INTERNAL SWEEP X100.

(f) Change the 50-volt signal to a 0.5-volt peak-to-peak sine wave from the voltmeter calibrator.

(g) If necessary, adjust the X100 Gain, R223, for 5.5-centimeters of deflection. See figure 5-4 for R223 location. Disconnect the voltmeter calibrator. Reconnect the yellow lead unless the frequency response should also be checked, as in paragraph 5-4d(3).

(h) Set the HORIZONTAL DISPLAY control to .1 VOLTS/CM and the horizontal AC-DC switch to AC.

(i) Connect a 1-volt peak-to-peak sine wave from the voltmeter calibrator to the horizontal INPUT, and, if necessary, adjust the Ext. Gain control, R212 (see figure 5-4), to give 10-centimeters horizontal deflection.

(3) FREQUENCY COMPENSATION. —

(a) Turn instrument off and disconnect yellow lead from circuit board A101, if not already disconnected in previous adjustments.

(b) Connect the 75-ohm output of the Model 211A Square Wave Generator to etched circuit board A101 at the point from which the yellow lead was removed.

(c) Connect the SWEEP OUTPUT connector to the vertical INPUT.

(d) Turn the instrument ON and allow a few minutes warm-up time.

(e) Set the HORIZONTAL DISPLAY control to INTERNAL SWEEP X5 and the SWEEP TIME to .5 MILLISECONDS/CM.

(f) Set the vertical SENSITIVITY control to obtain a vertical sweep trace 4-centimeters long. Set the square wave generator frequency to 4 kc and the output amplitude as necessary to produce a 3-centimeter wide square wave.

(g) Adjust the Sweep Gain Comp trimmer, C201 (see figure 5-4), to flatten the square wave, if necessary.

(h) Set the HORIZONTAL DISPLAY control to X10 and the SWEEP TIME to 20 MICROSECONDS/CM.

(i) Set the square wave generator frequency to 100 kc and the output to give about a 5-centimeter deflection.

(j) Adjust the L.F. Comp capacitors C211 and C213 (see figure 5-3) for an approximately flat-topped square wave, if necessary.

(k) Increase the Cap Driver Adj. trimmer, C216 (see figure 5-3), until some overshoot appears on the left side of square wave; then readjust until this overshoot just disappears.

(l) Increase the square-wave amplitude to maximum and adjust the HORIZONTAL POSITION control until the right side of the square wave is just visible on the left edge of CRT (most of the square wave is off the CRT to the left). Overshoot will appear on square wave.

(m) Readjust the L.F. Comp capacitors C211 and C213 until peak of overshoot is even with top of the square wave.

(n) Disconnect the square wave generator, turn off the oscilloscope, and reconnect the yellow wire to etched circuit board A101.

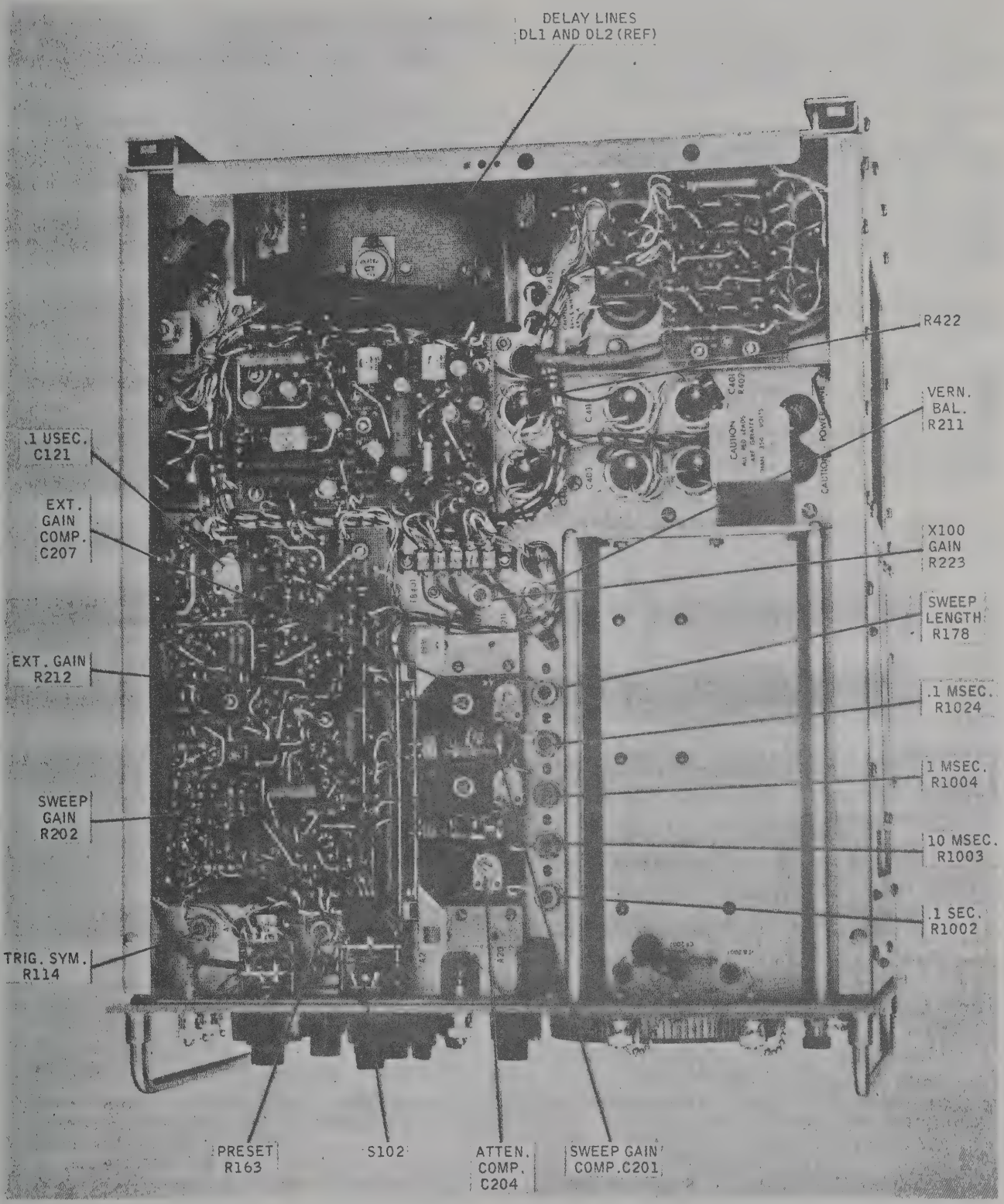


Figure 5-4. Bottom View, Location of Adjustments

(o) Connect a jumper from the junction of R143 and the white/yellow/violet wire on the etched circuit board A101 (see figure 5-17) to test point A3 at the white/violet wire (see figure 5-2).

(p) Turn on the instrument, and set the HORIZONTAL DISPLAY control to .5 VOLTS/CM and the SWEEP TIME control to .1 MILLISECONDS/CM.

(q) Connect the SWEEP OUTPUT to Channel A INPUT.

(r) Connect the 75-ohm output of the square wave generator to the horizontal INPUT, set square wave frequency to 4 kc, and adjust its amplitude to make square wave about five-centimeters wide on CRT.

(s) Set the vertical SENSITIVITY to make the sweep (now vertical) about four-centimeters high.

(t) Adjust the Ext. Gain Comp trimmer, C207 (see figure 5-4), to flatten the square wave, if necessary.

(u) Set the HORIZONTAL DISPLAY control to 1 VOLTS/CM and adjust the square wave generator output to obtain a five-centimeter wide square wave.

(v) Adjust the Atten Comp trimmer, C204 (see figure 5-4), to flatten the square wave, if necessary. Remove the jumper installed in step o.

e. SWEEP GENERATOR ADJUSTMENT. — The location of test points and adjustments in the sweep generator is shown in figures 4-18 and 5-4. For parts location refer to figures 5-10 and 5-17.

(1) PRESET SENSITIVITY AND TRIGGER SYMMETRY. —

(a) Remove the oscilloscope from the cabinet, turn it on, and allow a five-minute warm-up period.

(b) Set the HORIZONTAL DISPLAY control to INTERNAL SWEEP X1 and the SWEEP TIME control to 1 MILLISECONDS/CM or faster.

(c) Measure the voltage at test point D20 (see figure 4-18) while slowly rotating the SWEEP MODE control from just out of PRESET to FREE RUN. Note the voltage at which the sweep starts (meter pointer jumps).

(d) Set the SWEEP MODE control to PRESET.

(e) Set the Preset Adj. control, R163 (see figure 5-4), fully counterclockwise, then turn it clockwise to obtain a voltmeter reading of exactly 1.5 volts less negative than the reading noted in step c.

(f) Set the TRIGGER SOURCE control to INT, the SWEEP MODE control to FREE RUN, the TRIGGER SLOPE control to +, and the SWEEP TIME control to .5 MILLISECONDS/CM.

(g) Connect the CALIBRATOR output to Channel A INPUT and set the Vertical Presentation Switch to CHANNEL A.

(h) Set the CALIBRATOR control, vertical SENSITIVITY control, and sensitivity VERNIER control to obtain 0.2-centimeter vertical deflection.

(i) Ground pin 7 of V101 with a jumper (see figures 5-6 and 5-17).

(j) Set SWEEP MODE control to PRESET and adjust Trig Sym. control, R114 (see figure 5-4), to obtain a triggered sweep. Remove the ground jumper from V101.

(2) SWEEP LENGTH AND SWEEP RATE. —

(a) Set the HORIZONTAL DISPLAY control to INTERNAL SWEEP X1, the SWEEP TIME control to 20 MILLISECONDS/CM, and the SWEEP MODE control to FREE RUN.

(b) Connect the CALIBRATOR output to the vertical INPUT and set the CALIBRATOR and vertical SENSITIVITY to obtain a 5-centimeter vertical deflection.

(c) Adjust the TRIGGER LEVEL control to obtain the shortest possible sweep.

(d) Adjust the Sweep Length control R178 (see figure 5-4) to obtain a sweep trace length exactly 11-centimeters long.

(e) Set the SWEEP MODE control to PRESET and the TRIGGER SOURCE control to EXT. AC.

(f) Connect the AN/USM-108 Time-Mark Generator to the vertical INPUT and connect the time-mark generator trigger output to the TRIGGER SOURCE INPUT.

TABLE 5-10. SWEEP CALIBRATION

Sweep Time	Marker	Adjust	Adjust For
.1 msec/cm	100 μsec	.1 msec Timing R1024	1 marker/cm
1 msec/cm	1 msec	1 msec Timing R1004	1 marker/cm
10 msec/cm	10 msec	10 msec Timing R1003	1 marker/cm
.1 sec/cm	100 msec	.1 sec Timing R1002	1 marker/cm
.1 μsec/cm	10 mc (sine wave)	.1 μsec Timing C121 (on circuit board A101)	1 cycle/cm
.02 μsec/cm (HORIZONTAL DISPLAY set to X5)	10 mc (sine wave)	H. F. Comp C212 and C214 (on circuit board A202)	Adjust to equal values to make signal symmetrical about center line of graticule.
.2 μsec/cm	5 mc (sine wave)	.2 μsec Timing C1016	1 cycle/cm
.5 μsec/cm	1 μsec	.5 μsec Timing C1014	1 marker/2 cm
1 μsec/cm	1 μsec	1 μsec Timing C1012	1 marker/cm
10 μsec/cm	10 μsec	10 μsec Timing C1010	1 marker/cm

(g) Set the vertical SENSITIVITY to obtain easily read vertical deflection of markers.

(h) Refer to table 5-10 to select sweep time and time-mark generator output and to adjust indicated control. See figures 5-4, 5-17, and 5-18, for adjustment locations.

f. MAIN VERTICAL AMPLIFIER ADJUSTMENT. — Location of test points and adjustments in the main vertical amplifier is shown in figures 4-19 and 5-3. For location of parts refer to figure 5-14.

(1) LOW-FREQUENCY GAIN. —

(a) Remove the oscilloscope from the cabinet, turn it ON, and allow a five-minute warm-up.

(b) Remove the vertical plug-in unit and install the test connector shown in figure 5-1.

(c) Connect a 0.8-volt peak-to-peak 400-cps signal from the Model 738A Voltmeter Calibrator to the connector, as shown in table 5-7, step 10; set the oscilloscope controls as follows:

HORIZONTAL DISPLAY to X1
SWEEP TIME to 2 MILLISECONDS/CM
TRIGGER SOURCE to INT
SWEEP MODE to PRESET
TRIGGER LEVEL to 0

(d) Adjust the Vert Gain control, R13 (see figure 5-3), to produce exactly 4-centimeters vertical deflection on CRT. Disconnect the voltmeter calibrator.

(2) HIGH FREQUENCY COMPENSATION AND PULSE RESPONSE. —

(a) Set the TRIGGER SOURCE control to INT, the SWEEP MODE control to PRESET, and the SWEEP TIME control to .5 MICROSECONDS/CM.

(b) Connect a Model 107 Square Wave Generator to the test connector. Set the square wave generator frequency to 0.5 megacycles and the output amplitude to obtain 3-centimeters vertical deflection on the CRT.

(c) Be sure the vertical deflection plate leads have maximum clearance between adjacent leads and any chassis parts.

(d) If necessary, adjust the Hi Freq Comp capacitor, C31 (see figure 5-3), to produce a flat-topped square wave. Ignore any high-frequency ringing at this time.

(e) Center the square wave vertically, and adjust the Pulse Response Adjust capacitor, C20 (see figure 5-3), to obtain the best leading edge on the square wave. Any ringing in step d should now decrease in amplitude. Disconnect the square wave generator.

(f) Perform the vertical passband test in table 5-7, step 11. If the passband is not equal to or greater than 30 megacycles (35 megacycles is typical) repeat steps d and e compromising the ideal square wave, but with overshoot not to exceed 0.05 centimeters.

g. MX-2930B/USM VERTICAL PLUG-IN. — Location of test points and adjustments in the MX-2930B/USM Vertical Plug-In is shown in figures 4-21, 4-22, and 5-5. For location of parts refer to figures 5-30 through 5-34.

(1) BALANCE. —

(a) Set the Vertical Presentation Switch to CHANNEL A and the SWEEP MODE switch to FREE RUN.

(b) Center the sweep vertically with the Channel A VERTICAL POSITION control.

(c) Adjust Channel A BAL, R508 (see figure 5-30), to obtain no vertical shift on the trace as the Channel A POLARITY switch is turned from +UP to -UP.

(d) Repeat the above for Channel B, setting the associated BAL control, R543 (see figure 5-30).

(2) SENSITIVITY. —

(a) Set the Vertical Presentation Control to CHANNEL A, the AC-DC switch to AC, the VERNIER adjustment to CALIBRATED, and the SENSITIVITY control to 0.02 VOLTS/CM.

(b) Set the HORIZONTAL DISPLAY control to X1, the SWEEP TIME control to 50 MICROSECONDS/CM, the SWEEP MODE control to PRESET, and the TRIGGER SOURCE switch to INT.

(c) Apply 400-cycle sine wave from a Model 738A Voltmeter Calibrator to the Channel A INPUT; set the amplitude to .05 volt peak-to-peak.

(d) Adjust the SENS CAL control for a CRT deflection height of exactly 2.5 centimeters. See figure 5-30.

(e) Check all the other ranges of the SENSITIVITY control and adjust the SENS CAL control if necessary for agreement with the following list.

SENSITIVITY VOLTS/CM	Peak-to-Peak Input Voltage	Display Height (centimeters)
0.02	0.05	2.5
0.05	0.2	3.88 to 4.12
0.10	0.3	2.91 to 3.09
0.20	0.5	2.42 to 2.58
0.50	2.0	3.88 to 4.12
1.00	3.0	2.91 to 3.09
2.00	5.0	2.42 to 2.58
5.00	20.0	3.88 to 4.12
10.0	30.0	2.91 to 3.09
20.0	50.0	2.42 to 2.58

(f) Repeat the above for Channel B, setting the associated SENS CAL control.

(3) INPUT CAPACITANCE. —

(a) Set the Vertical Presentation Switch to CHANNEL A and the Channel A SENSITIVITY control to .02 VOLTS/CM.

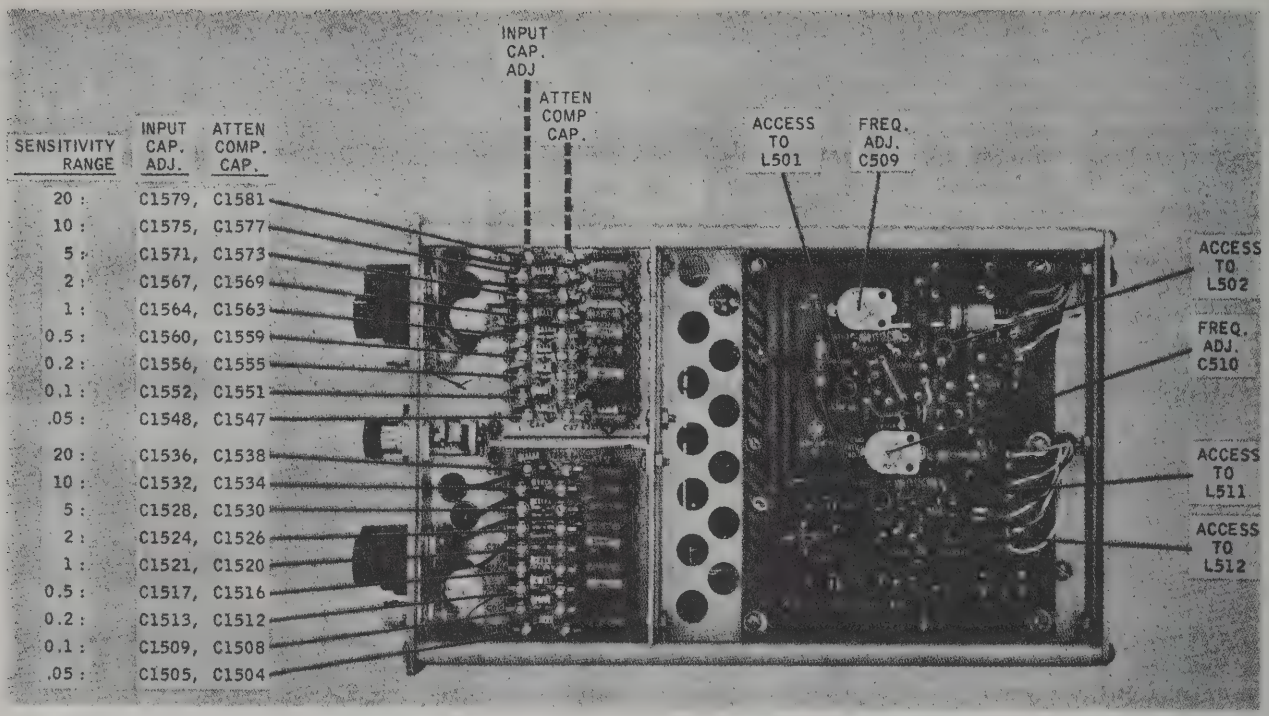
(b) Connect the AN/URM-90 Q Meter to the Channel A INPUT and adjust the A Cap Adj, C1590, to make the input capacitance 30 pf.

(c) Set the Channel A SENSITIVITY switch as indicated in the list below, and adjust each indicated capacitor for 30 pf. See figure 5-5 for location.

(d) Set the Vertical Presentation Switch to CHANNEL B and the Channel B SENSITIVITY control to .02 VOLTS/CM.

(e) Connect the capacity meter to the Channel B INPUT and adjust the B Cap Adj, C1594, to make the input capacitance 30 pf.

(f) Set the Channel B SENSITIVITY switch as indicated in the table below, and adjust each indicated capacitor for 30 pf. See figure 5-5 for location.



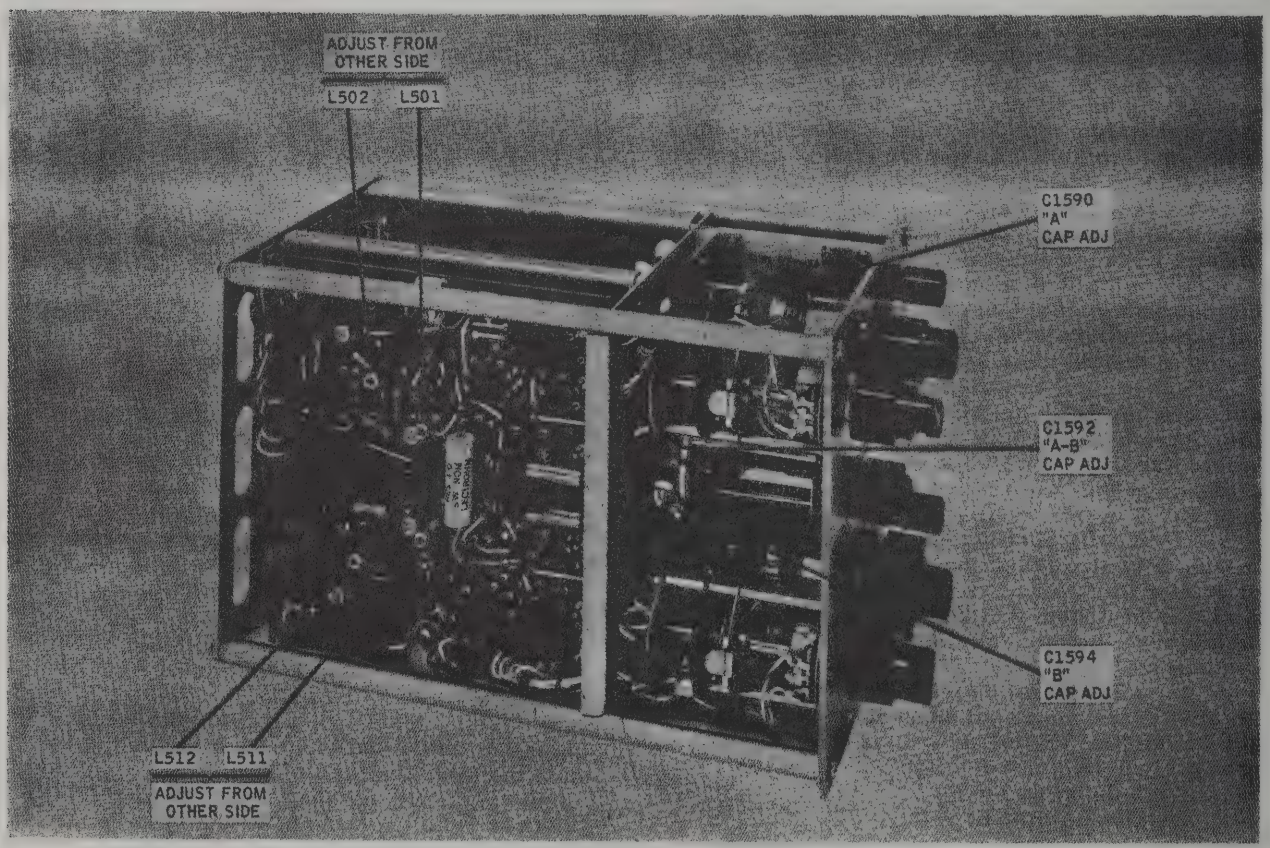


Figure 5-5. Location of Adjustments in MX-2930B/USM

(g) Set the Vertical Presentation Switch to A-B and both SENSITIVITY switches to .02 VOLTS/CM. Adjust the A-B Cap Adj, C1592, to make input capacitance 30 pf.

SENSITIVITY VOLTS/CM	ADJUST	Channel A	Channel B
.05	.05 Cap Adj	C1548	C1505
.1	.1 Cap Adj	C1552	C1509
.2	.2 Cap Adj	C1556	C1513
.5	.5 Cap Adj	C1560	C1517
1	1 Cap Adj	C1564	C1521
2	2 Cap Adj	C1567	C1524
5	5 Cap Adj	C1571	C1528
10	10 Cap Adj	C1575	C1532
20	20 Cap Adj	C1579	C1536

(4) ATTENUATOR COMPENSATION. —

(a) Set the Vertical Presentation Switch to CHANNEL A and connect the 600-ohm output of a Model 211A Square Wave Generator to the Channel A INPUT; set the square-wave frequency to 5 kc.

(b) Set the HORIZONTAL DISPLAY control to INTERNAL SWEEP X1, the SWEEP TIME switch to 5 MILLISECONDS/CM, the TRIGGER SOURCE switch to INT, and the SWEEP MODE control to PRESET.

(c) Set the Channel A SENSITIVITY as indicated in the list below. In each case adjust the square wave generator output amplitude for 2- or 3-centimeters of deflection and adjust the indicated capacitor for the best square wave on the CRT. See figure 5-5 for locations.

(d) Set the Vertical Presentation Switch to CHANNEL B and change the square wave generator output to the B INPUT.

(e) Repeat steps b and c above for Channel B controls.

SENSITIVITY VOLTS/CM	ADJUST	Channel A	Channel B
.05	.05 Atten Comp	C1547	C1504
.1	.1 Atten Comp	C1551	C1508
.2	.2 Atten Comp	C1555	C1512
.5	.5 Atten Comp	C1559	C1516
1	1 Atten Comp	C1563	C1520
2	2 Atten Comp	C1569	C1526
5	5 Atten Comp	C1573	C1530
10	10 Atten Comp	C1577	C1534
20	20 Atten Comp	C1581	C1538

(5) HIGH FREQUENCY RESPONSE. —

(a) Set the Vertical Presentation Switch to CHANNEL A, the Channel A SENSITIVITY to .02 VOLTS/CM, and the VERNIER to CALIBRATED.

(b) Set the HORIZONTAL DISPLAY control to INTERNAL SWEEP X1, the SWEEP TIME switch to .5 MICROSECONDS/CM, the TRIGGER SOURCE control to INT, and SWEEP MODE to PRESET.

(c) Connect a fast-rise square wave generator to the Channel A INPUT. Adjust the square-wave frequency for 2 or 3 cycles on the CRT and 4- or 5-centimeters of deflection.

(d) Adjust the High Freq coils L501 and L502 for the best square wave with minimal overshoot. Although these coils are on the left side of the Dual Trace Preamplifier, they are adjusted from right side through special holes in the circuit board (see figure 5-5).

(e) Repeat steps a through d for Channel B; adjust the High Freq coils L511 and L512 for minimum overshoot.

(6) SWITCHING MULTIVIBRATOR FREQUENCY. —

(a) Set the HORIZONTAL DISPLAY control to INTERNAL SWEEP X1, the SWEEP TIME control to .1 MICROSECONDS/CM, the VERNIER to CAL, the TRIGGER SOURCE switch to INT, the SWEEP MODE control to FREE RUN, and the INTENSITY MODULATION control to EXTERNAL.

(b) Set the Vertical Presentation Switch to ALTERNATE and adjust the VERTICAL POSITION controls for two traces about 4 centimeters apart.

(c) Set the Vertical Presentation Switch to CHOPPED and the SWEEP MODE control to PRESET.

(d) Adjust Freq Adj capacitors C509 and C510 for symmetrical square wave 10-centimeters long (neglect transients during switching).

5-5. REPLACEMENT OF COMPONENTS.

a. TUBES. — Electron tubes are best checked by replacement. Results obtained from an external tube tester can sometimes be misleading. Mark the tubes for identification as you remove them so you can return them to their original sockets if they are still good. Figure 5-6 shows the locations of the tubes and table 3-4 indicates the adjustments required following replacement of tubes, transistors, and diodes. Tube type 7308 may be replaced, in emergencies, by tube type 6922. The latter type, however, draws a different heater current and may unbalance the heater supplies. If such a substitution is made, check the ±6.3 volt supplies to assure that they are within 0.2 volts of each other. Balance can be restored by tube selection.

b. TRANSISTORS AND DIODES. — For the general procedure for component replacement on etched circuit boards, refer to paragraph 5-5f. Transistors on etched circuit boards are mounted on insulated spacers that provide added support for the pigtail leads. The simplest way to remove a transistor is to cut its leads, remove and save the spacer, and unsolder the ends of the leads that are left in the board. When removing these remaining leads, use a toothpick or a small awl to clear the holes of softened solder. Avoid excessive heat, and always insulate the instrument from ground or ground the body of the

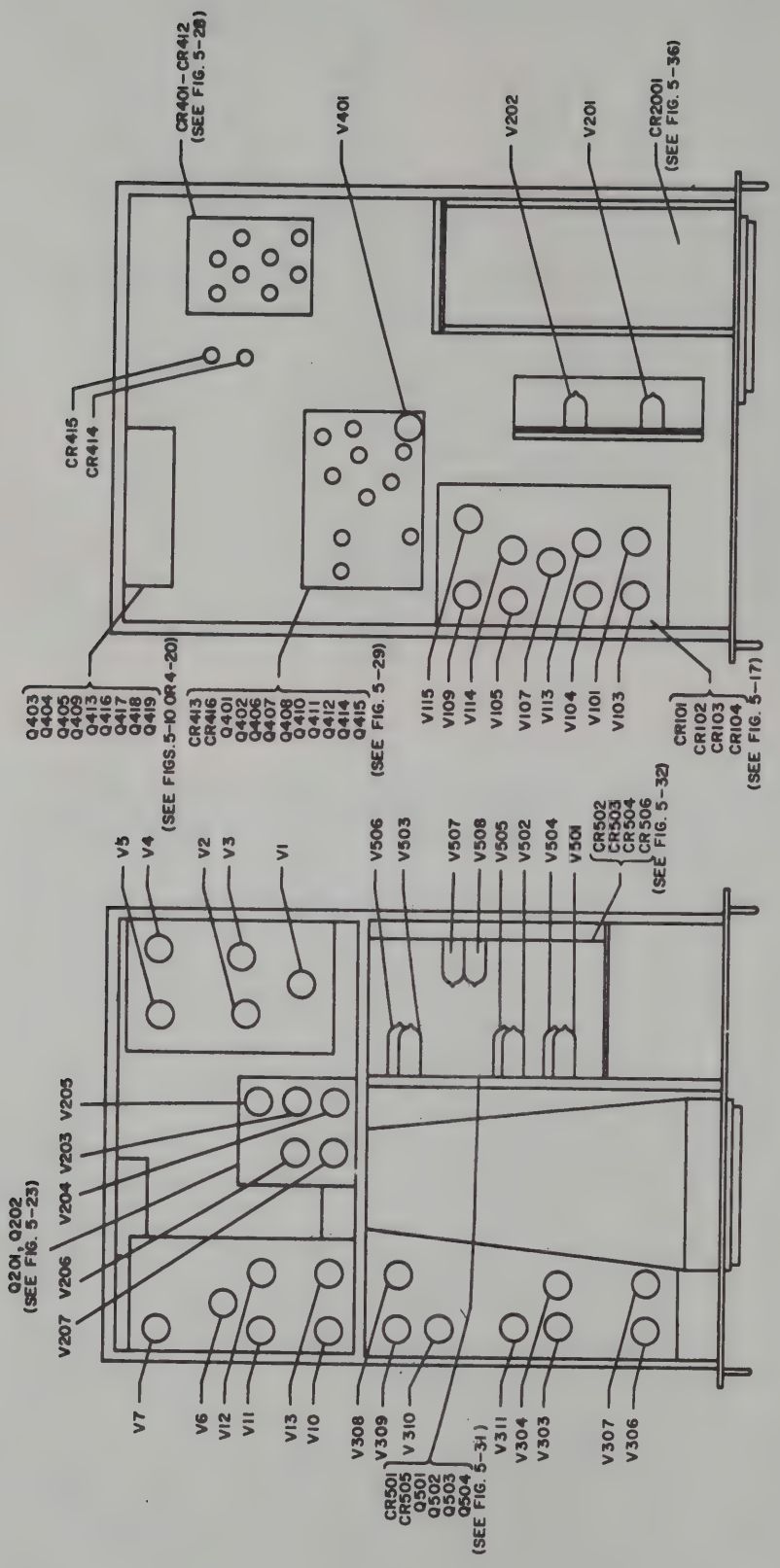


Figure 5-6. Top and Bottom Views, Location of Electron Tubes

soldering iron to prevent leakage voltage from damaging the component. When connecting the replacement transistor, place the insulated spacer on the new transistor and trim the leads so they will penetrate the board about 1/16 inch with the transistor positioned about 1/8 inch above the board. Solder the leads with an absolute minimum of heat necessary to completely melt the solder. If possible, place a heat sink (such as a pair of needlenosed pliers) between the transistor and the soldering iron. Because of the inherent stability of transistors, they should be the last elements suspected in case of equipment failure. When other elements have been checked in the defective circuit, locate open or shorted transistors by resistance measurements across the elements. Because of the difference in ohmmeters, no specific information can be given about exact resistances; however, generally the ratio of forward and backward emitter-collector resistance is from 10:1 to 100:1, the ratio being lower for the higher powered transistors. When a defective transistor is located, always look for another faulty element in the circuit which might have caused its failure.

c. REMOVAL OF CATHODE RAY TUBE. — To remove the CRT, refer to figure 5-7 and proceed as follows:

WARNING

Wear plastic face mask or goggles and gloves when handling the cathode ray tube. Flying glass and internal parts of the CRT caused by implosion can cause severe injury. Tube is not dangerous if handled with due care.

(1) Remove the oscilloscope from cabinet, and place chassis upright.

(2) Remove 5 deflection plate terminals.

(3) Loosen two screws holding clamp on CRT base. Do not remove screws or clamp.

(4) Remove post-accelerator cap from CRT (see figure 5-7) by prying.

(5) Remove four mounting screws from bezel and remove bezel, filter, and graticule.

(6) Slide CRT slightly forward and loosen rubber gaskets between the clamp and CRT.

(7) Disconnect leads from neck of CRT and remove socket from CRT base.

(8) Slide CRT forward out of instrument, keeping one hand on front face of the CRT.

To install CRT, reverse above procedure. When the CRT is installed, turn the instrument on, obtain a free-running sweep, and check sweep alignment with horizontal lines on the graticule. If necessary, loosen the clamp on the CRT base and rotate the CRT by means of the tab on the socket to align the sweep with the graticule.

d. REMOVAL OF HIGH-VOLTAGE POWER SUPPLY TUBES. — The four high-voltage rectifier tubes, the oscillator, and regulator tubes are located under a cover accessible through the left side gusset (see figures 5-6 and 5-12). To remove the cover, remove the four machine screws securing the cover to the high-voltage power supply. Disconnect oscilloscope from power source before working on any part of the high-voltage supply. Short the tube plate caps to ground before removing them from the tubes. To remove the four rectifier tubes remove the insulator plate that secures the tubes.

e. ACCESS TO SWEEP GENERATOR TUBES. — The sweep generator tubes may be reached by removing the MX-2930B/USM Vertical Plug-In and

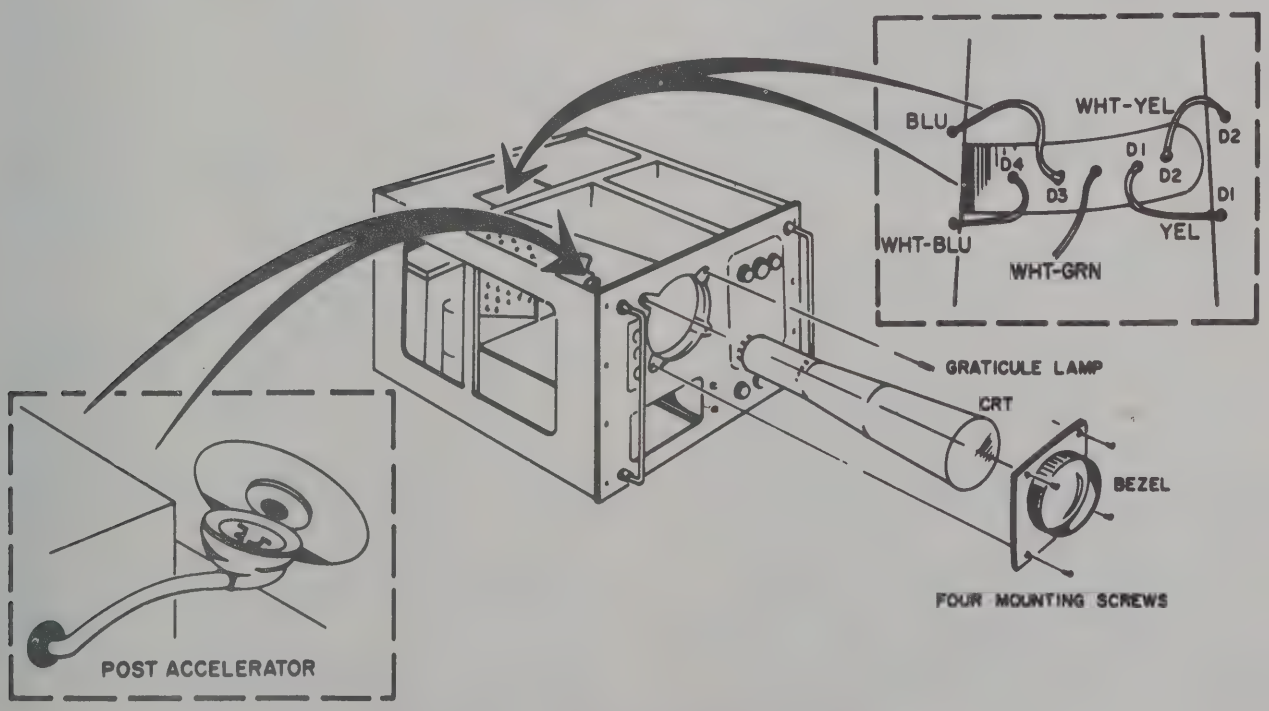


Figure 5-7. Removal of Cathode-Ray Tube

the shield plate in the floor on the empty plug-in well. Two screws hold the shield in place. Return the shield before replacing the plug-in unit. Refer to figure 5-6.

f. COMPONENT REPLACEMENT ON ETCHED CIRCUIT BOARDS. — If a circuit board must be removed, first release tube clamps and remove all electron tubes. Use a low-power soldering iron (50 watts maximum) and apply heat sparingly to the lead of the part to be replaced. Slip the lead from the board as soon as the solder softens. For transistors and diodes, see the special procedure in paragraph 5-5b. Use a small awl or toothpick to clean the softened solder from the lead hole in the board. Bend the tinned leads of the replacement part and carefully insert through the cleaned holes. Hold the part against the board and, when possible, solder the leads from the other side. Avoid overheating and use ONLY a high quality rosin-core solder. NEVER USE PASTE FLUX. After soldering trim off excess leads and flux.

A break in the copper should be repaired by soldering a short length of tinned copper wire across the break. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties. When replacing tube sockets cut all contacts to remove socket, then unsolder the remains.

When reinstalling the board, carefully align tube retainers with their respective chassis holes. Do not force the board into place by turning down on the mounting screws.

g. ACCESS TO FAN AND POWER SUPPLY TRANSISTORS. — The fan motor and certain power supply transistors are mounted on the fan shroud.

(1) For removal of the fan assembly and location of the power transistors, refer to paragraph 5-2b and figures 4-20 and 5-10.

(2) To remove the fan blades, use the 1/8 inch Allen wrench mounted on the rear of the chassis. There is an access port for this wrench on the bottom of the fan shroud. Turn the fan blades until the socket head screw is visible.

h. REPLACEMENT OF HORIZONTAL DISPLAY SWITCH ASSEMBLY A200. —

Note

Read and understand each step before starting this procedure. See figure 5-21.

(1) Remove the cabinet and both plug-in units.

(2) Set the HORIZONTAL DISPLAY switch S202 to X100 and the EXTERNAL VERNIER switch to CAL.

(3) Remove both knobs with the #8 Allen wrench mounted on rear chassis of instrument.

(4) Remove and save the front-panel mounting nut from the switch.

(5) Rear support bracket of switch S202 is part of the assembly. Remove and save the two screws holding the bracket to the chassis.

(6) Remove and save the shaft locknut and mounting hardware for the Vern Bal control R211 (figure 5-4).

(7) Remove and save shaft locknut and mounting hardware for the X100 Gain control R211 (figure 5-4).

(8) At the insulated terminal of the tie lug strip on the mounting bracket of switch S202, disconnect the white lead from the center terminal of R223 (see figure 5-21).

(9) At the grounded terminal of the tie lug strip, disconnect black wire from the cable.

(10) Disconnect the white, white/black, white/black/green, white/yellow, and the white/orange/green wires from etched circuit board A201. This wiring is indicated in figure 5-8.

(11) At the top of the AC-DC switch S201, disconnect the green wire from wafer A of S202.

(12) Remove the bottom shield plate of the plug-in unit well.

(13) Disconnect the white/brown/blue, white/brown/red, white/brown/orange, and white/brown/green wires from the top of wafer B of switch S202. These are the wires that go to the SWEEP TIME switch. See figures 5-21 and 5-42.

(14) Disconnect two white/brown wires at terminal on wafer C of switch S202 (47 ohm, 2 watt resistor also connected to this terminal).

(15) Remove and save two screws holding assembly of circuit boards A201 and A203 to chassis (figure 5-10).

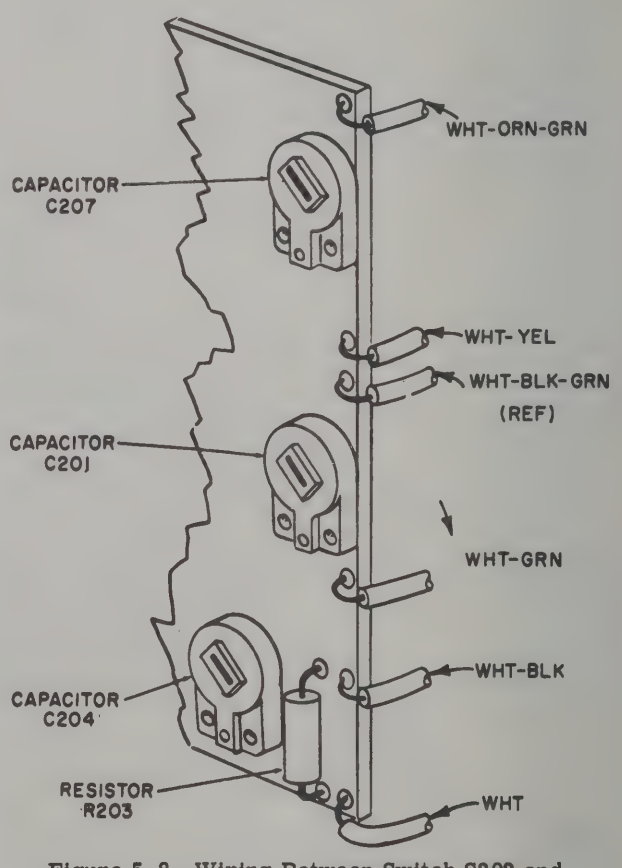


Figure 5-8. Wiring Between Switch S202 and Etched Circuit Board A201

(16) Cut off following wires as close as possible to terminals on S202.

(a) Violet and white/yellow/violet wire on wafer B.

(b) Green wire on bottom of wafer A.

(c) Two black wires on wafer A.

(d) White/green/violet wire on wafer C.

(e) White/yellow/blue wire on wafer C.

(f) Twisted pair of yellow and white/yellow wires on wafer E.

(g) White/yellow/green wire on wafer E.

(h) White/violet wire on rear of EXTERNAL VERNIER CAL switch S203.

(i) White/black/green wire on wafer A.

(17) Remove and discard defective switch assembly.

(18) Dress all leads on replacement switch toward bottom of switch except green lead from top of wafer A; white/brown/blue, white/brown/red, white/brown/orange, and white/brown/green from top of wafer B; white/brown wire from wafer C, white/yellow/green and twisted pair of yellow and white/yellow wires from wafer E.

(19) Insert replacement switch in instrument with shaft through front panel. Put on front-panel mounting nut and tighten finger tight. Be sure the switch positioning lugs on the front of switch engage holes in the rear of front panel. Press leads dressed toward bottom of switch through the hole toward circuit board A201.

(20) Connect and solder the green wire from top of wafer A to the top of AC-DC switch S201.

(21) Connect and solder one black lead from wafer A of S202 to ground terminal on sweep generator circuit board A101. Disconnect the black lead left from old switch.

(22) Connect and solder the remaining black lead from wafer A of S202 to terminal on top of circuit board A203 in place of black lead from old switch.

(23) Connect and solder the violet wire from wafer B of S202 to the center terminal of R1002 (.1 Sec Timing) in place of the violet wire from the old switch.

(24) Connect and solder the white/yellow violet wire from wafer B of S202 to one end of resistor R143 on sweep generator circuit board A101 in place of white/yellow/violet wire from old switch. Dress new wire along same route as old wire.

(25) Dress the white/brown/blue, white/brown/red , white/brown/orange, and white/brown/green wires from wafer B of S202 over to SWEEP TIME switch S1001 and connect and solder them to separate terminals on wafer A of S1001 as shown in figure 5-18.

(26) White/yellow/blue wire from wafer D of S202 should be connected to R223. However, it is easier to connect the old wire to terminal of wafer D of S202 in place of new white/yellow/blue wire supplied with replacement switch.

(27) White/yellow/green wire from wafer E of S202 should be connected to R223. However, it is easier to connect old wire to terminal of wafer E of S202 in place of white/yellow/green wire supplied with replacement switch.

(28) White/violet wire from EXTERNAL VERNIER CAL switch S203 should be connected to circuit board A203. However, it is easier to connect old wire to S203 in place of white/violet wire supplied with replacement switch.

(29) Route new twisted pair of yellow and white/yellow wires from wafer E of S202 along same path as wires from original switch and connect new wires in place of old ones. Connect yellow wire to junction of R224 and C211 on horizontal amplifier circuit board A202; connect white/yellow wire to junction of R259 and C213 on same board.

(30) Connect and solder white/brown wire from the Vern Bal control R211 and white/brown wire from the SCALE LIGHT control R1025 to terminal on wafer C of S202 to which gray wire and 47-ohm, 2-watt resistor are connected. Remove and discard white/brown wire supplied on switch.

(31) White/green/violet wire from wafer C of S202 should be connected to circuit board A203. However, it is easier to connect old white/green/violet wire on wafer C of S202 in place of wire supplied with replacement switch.

(32) Remove mounting nut from switch S202 and slide back to gain access to bottom terminal on wafer A to which green wire is attached.

(33) Replace the green wire from bottom of wafer A of switch S202 with green wire from circuit board A203.

(34) Replace white/black/green wire on bottom of wafer A to J201.

(35) Slide switch forward through panel and engage switch position lugs in holes on rear side of front panel. Replace front-panel mounting nut and tighten finger tight.

(36) All wires from S202 except the following five wires (and one white wire off S203) should be connected by previous steps:

(a) White/yellow wire from EXTERNAL VERNIER CAL switch S203.

(b) White/orange/green and white/black/green wires from wafer C.

(c) White and white/black wires from wafer A.

(37) Dress the five wires identified above so they are in sequence for connecting to circuit board A201 (see figure 5-8).

(38) Remount assembly of circuit boards A201 and A203 on chassis. Use two 6-32 x 3/4 inch mounting screws and #6 internal-tooth lockwasher under each screw head.

(39) Refer to figure 5-8 and connect five wires identified in step 37 to circuit board A201.

(40) Replace but do not tighten two 6-32 x 3/8 inch mounting screws for switch S202 rear mounting bracket. Place 6 x 3/8 inch flat washer under each screw head.

(41) Tighten front-panel mounting nut.

(42) Be sure no wires are pinched under switch S202 rear mounting bracket and tighten mounting bracket screws.

(43) Remount the X100 Gain control R223. Place internal-tooth lockwasher under mounting nut.

Be sure locating lug is in corresponding chassis hole before tightening mounting nut. Be sure no wires are pinched under control.

(44) Remount Vern Bal control R211. Follow same procedure given for R223 above.

(45) Replace shaft locknuts on R223 and R211.

(46) Connect and solder the white wire from the center terminal of the Vern Bal control R211 to insulated terminal of tie lug strip on the rear mounting bracket of S202.

(47) Connect and solder the black wire from cable to the grounded terminal of tie lug strip on the rear mounting bracket of S202.

(48) Replace the black knob on the HORIZONTAL DISPLAY switch S202. Be sure switch is rotated fully clockwise. Tighten both setscrews with knob pointer in X100 position.

(49) Replace the red knob on the EXTERNAL VERNIER control shaft. Rotate shaft fully clockwise to CAL position and tighten knob so pointer points to CAL.

(50) Replace bottom plate of vertical plug-in unit amplifier well. Use two 6-32 x 3/8 inch machine screws with lockwashers.

(51) Switch replacement is complete. Before putting instrument back into service, check horizontal amplifier adjustment (paragraph 5-4d).

i. REPLACEMENT OF SWEEP TIME SWITCH ASSEMBLY A1000. —

Note

Read and understand each step before starting this procedure.

(1) Remove the cabinet and both plug-in units.

(2) Remove the knobs from the SWEEP TIME switch (S1001) and VERNIER control. Use the #8 Allen wrench mounted on rear chassis of instrument.

(3) Remove and save the front-panel mounting nut.

(4) Remove the bottom shield plate of the vertical plug-in unit well. This plate is held in place by two screws.

(5) Examine the coupling at the inner end of the center shaft of switch S1001. A small hairpin-shaped coupler connects the shaft to R1009.

(6) Loosen but do not remove the mounting nut of R1009 and slide the control back far enough to free the coupler.

(7) Remove the coupler from the end of the shaft and save it.

(8) Remove and save washer(s), spacers, "O" ring, and spacer on the end of the shaft.

(9) Pull the shaft forward out of the instrument.

(10) Mark all tubes so they can be returned to the same sockets and remove V101, V113, V107, V114, and V115.

(11) Remove and save both screws holding mounting rear bracket of S1001 to chassis.

(12) Trace the coax center conductor from wafer C of S1001 to the junction of R151 and CR104 on the sweep generator circuit board A101; disconnect this coax center conductor at the circuit board A101.

(13) Trace the yellow wire from wafer D on S1001 through the chassis hole to the terminal on circuit board A101. Disconnect this yellow wire from S101 at circuit board A101.

(14) Disconnect white/black/yellow wire at terminal on wafer A of S1001 and remove ties holding wire to S1001 frame.

(15) Disconnect white/brown/green, white/brown/orange, white/brown/red, and white/brown/blue wires at their respective terminals on wafer A of S1001.

(16) At the socket terminal for SWEEP UNCAL lamp DS1001, disconnect the brown wire from wafer A of S1001.

(17) Disconnect green wire from wafer D of S1001 at the rear terminal of 1.0 mfd 200 volt capacitor C1006.

(18) Disconnect the black wire from wafer D of S1001 at the front terminal of C1006.

(19) Disconnect the yellow wire on wafer D that goes to J105.

(20) Orange and white/orange/yellow wires connect two terminals of wafer B of S1001 to two terminals on the CAL switch S1002 on the rear of the VERNIER control R1009. These wires will be used for connections to the replacement switch. Cut both wires at terminals on wafer B of S1001.

(21) Cut the six-wire cable connecting to wafer B of S1001 and remove the defective switch. This cable consists of a white/orange, white/black, white/red, white/green, black, and a violet wire.

(22) Pull the cable cut in step 21 into compartment for auxiliary plug-in.

(23) Remove the center shaft from replacement switch and place switch in instrument. Pass the yellow wire (disconnected in step 13) from wafer D of S1001 through chassis hole with other wires when inserting switch.

(24) Route the six-wire cable from wafer B of the replacement switch along same path as the cable from original switch.

(25) To gain access to the terminals of controls R178, R1024, R1004, R1003, and R1002 (figure 5-4) remove the two mounting screws holding this assembly in place. Save screws and lockwashers.

(26) Observe color code and connect wires from replacement switch cable in place of wires from old switch:

(a) Black wire to ground terminal of tie lug strip on rear mounting bracket of HORIZONTAL DISPLAY switch S202.

(b) Violet wire to Sweep Length control R178.

(c) White/orange to .1 msec Timing control R1024.

(d) White/black to 1 msec Timing control R1004.

(e) White/red to 10 msec Timing control R1003.

(f) White/green to .1 sec Timing control R1002.

(27) Remount assembly of circuit boards A201 and A203. Use 6-32 x 3/4 inch screws and #6 internal-tooth lockwashers (see figure 5-10).

(28) Route the orange and white/orange/yellow wires (disconnected in step 20) through S1001 switch wafer to wafer B in place of wires with corresponding colors supplied on replacement switch. Connect the routed wires to wafer B terminals in place of supplied wires.

(29) Connect black wire from wafer D of S1001 to front terminal of 1.0 mfd 200-volt capacitor C1006. (See figure 5-40.)

(30) Connect the green wire from wafer D of S1001 to rear terminal of C1006.

(31) Connect the yellow wire from wafer D to J105. An easier method is to clip off the existing yellow wire and reconnect the old wire disconnected in step 19.

(32) Connect the brown wire from wafer A of S1001 to vacant socket terminal of SWEEP UNCAL lamp DS1001.

(33) Connect white/brown/green, white/brown/orange, white/brown/red, and white/brown/blue wires from HORIZONTAL DISPLAY switch S202 to their respective terminals on wafer A of S1001. See figure 5-40 for proper locations.

(34) Connect white/black/yellow wire (disconnected in step 14) from circuit board A302 to vacant terminal of rear side of wafer A of S1001. A 3.3-megohm resistor is connected to adjacent terminal. Use the same procedure as in step 31.

(35) Tie white/black/yellow wire to the frame of switch S1001 at wafers A and D.

(36) Connect the yellow wire from wafer D of S1001 to terminal on circuit board A101.

(37) Dress the coax inner conductor from wafer C of S1001 through the chassis hole and hole in circuit board A101. Connect this wire to the junction of R151 and CR104 on circuit board A101.

(38) Dress the coax inner conductor along chassis and between tubes V114 and V115. Leave no slack at board A101.

(39) Replace but do not tighten the two 6-32 x 3/8 inch and #6 x 3/8 inch O.D. flat washers for rear mounting bracket of S1001. Be sure switch positioning lugs on front of switch engage holes in rear of front panel.

(40) Replace and tighten the front-panel mounting nut; then tighten the two rear mounting screws. Be sure no wires are pinched under mounting bracket.

(41) Insert the new shaft through center of S1001 and replace spacer, "O" ring, and spacer on inner end of center shaft.

(42) Replace washer(s) removed from shaft in step 8 and replace the hairpin coupler on end of shaft.

(43) Engage the coupler in the slot on the end of the shaft of the VERNIER control R1009.

(44) Tighten the mounting nut for R1009.

(45) The center shaft of S1001 should have approximately 1/32 inch end play and coupler must fully engage slot in shaft of R1009. Washer(s) placed on center shaft in step 42 determine end play and can be varied in number to adjust end play.

(46) Replace the tubes V115, V114, V107, V113, and V101.

(47) Replace the bottom shield plate of vertical plug-in unit well. Use two 6-32 x 3/8 inch machine screws with lockwashers.

(48) Replace the black knob on the SWEEP TIME switch. Be sure the switch is rotated fully clockwise and tighten both setscrews with knob pointer in .1 MICROSECONDS/CM position.

(49) Replace the red knob on the VERNIER control shaft. Rotate the shaft fully clockwise to CAL and tighten both setscrews so the pointer points to CAL.

(50) Switch replacement is complete. Before putting the instrument back into service, check sweep calibration, paragraph 5-4e.

5-6. LOCATION OF PARTS.

Figures 5-9 through 5-36 show locations of parts. All replaceable components and subassemblies are identified on the illustrations by reference designation and cross-referenced in the tables adjacent to each large etched circuit assembly and schematic drawing. These tables identify the location of each part on the adjacent illustration by use of "map-type" coordinates. The parts list, table 6-2, also lists all components by reference designation, and table 6-2 cross-references the appropriate illustration in section 5 which shows the location of each part.

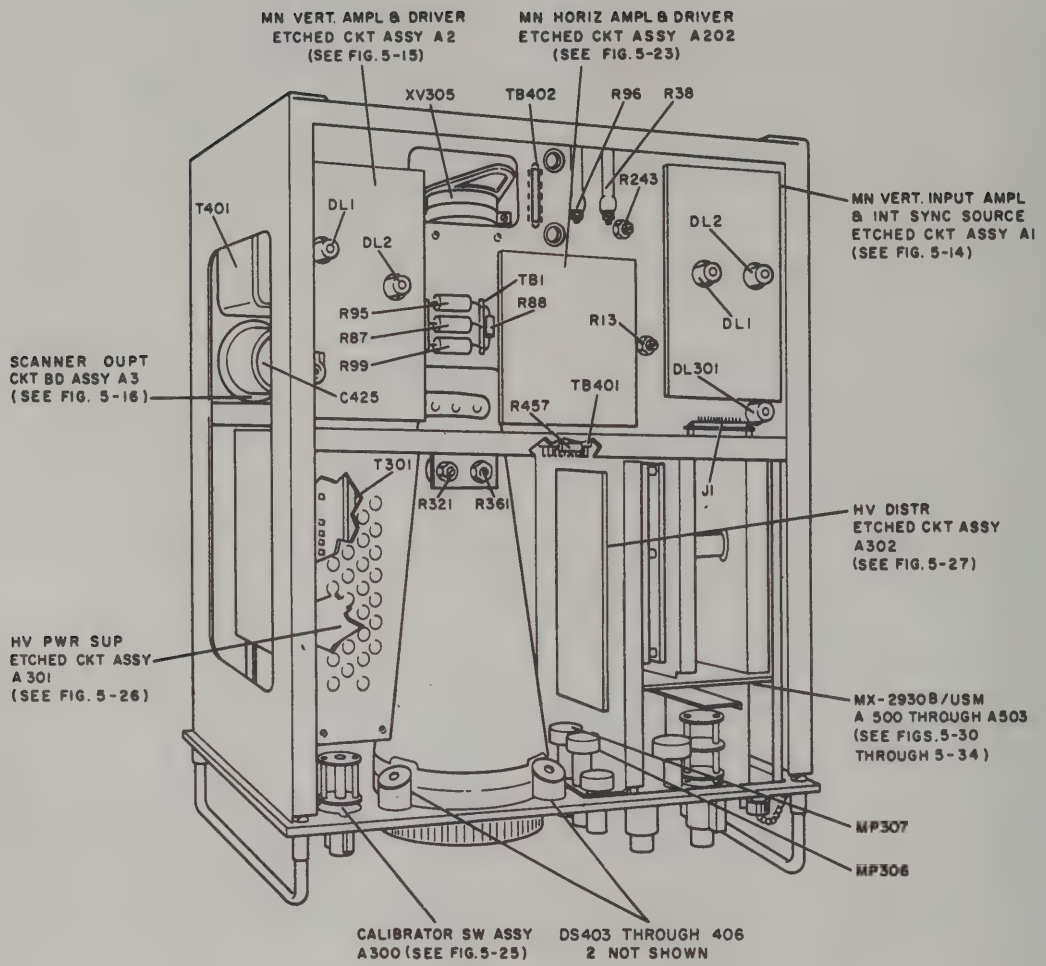


Figure 5-9. Top View, Location of Parts

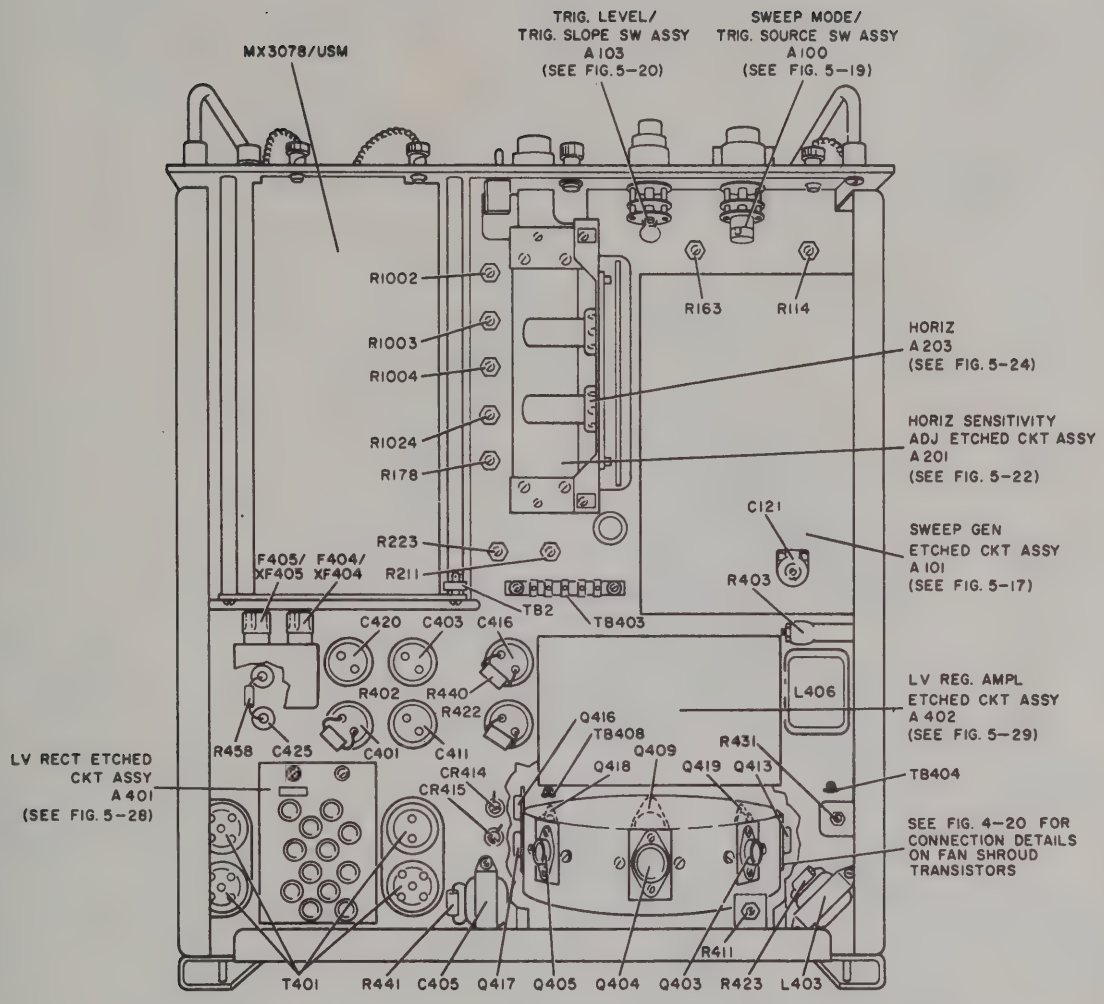


Figure 5-10. Bottom View, Location of Parts

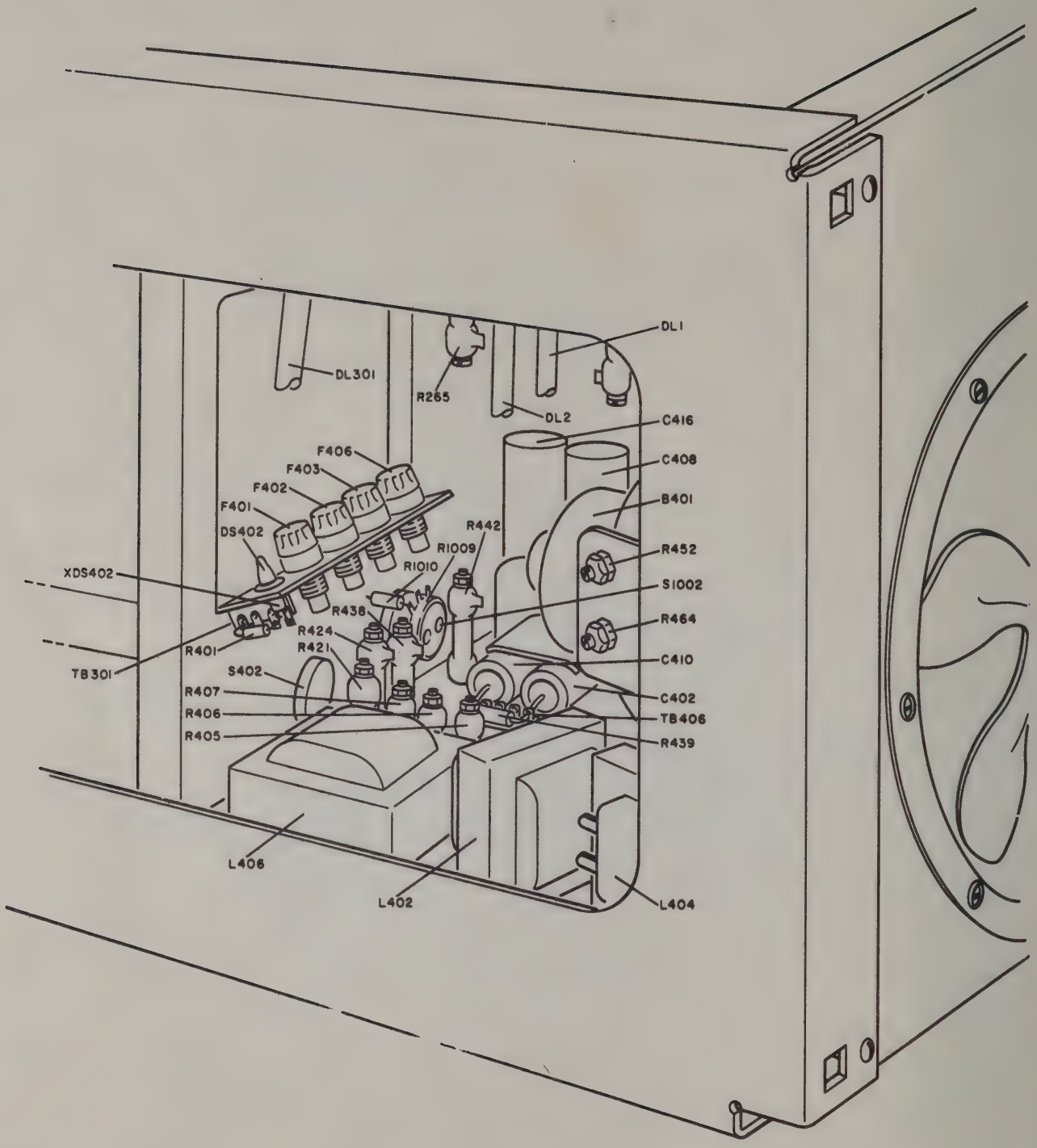


Figure 5-11. Right-Side View, Location of Parts

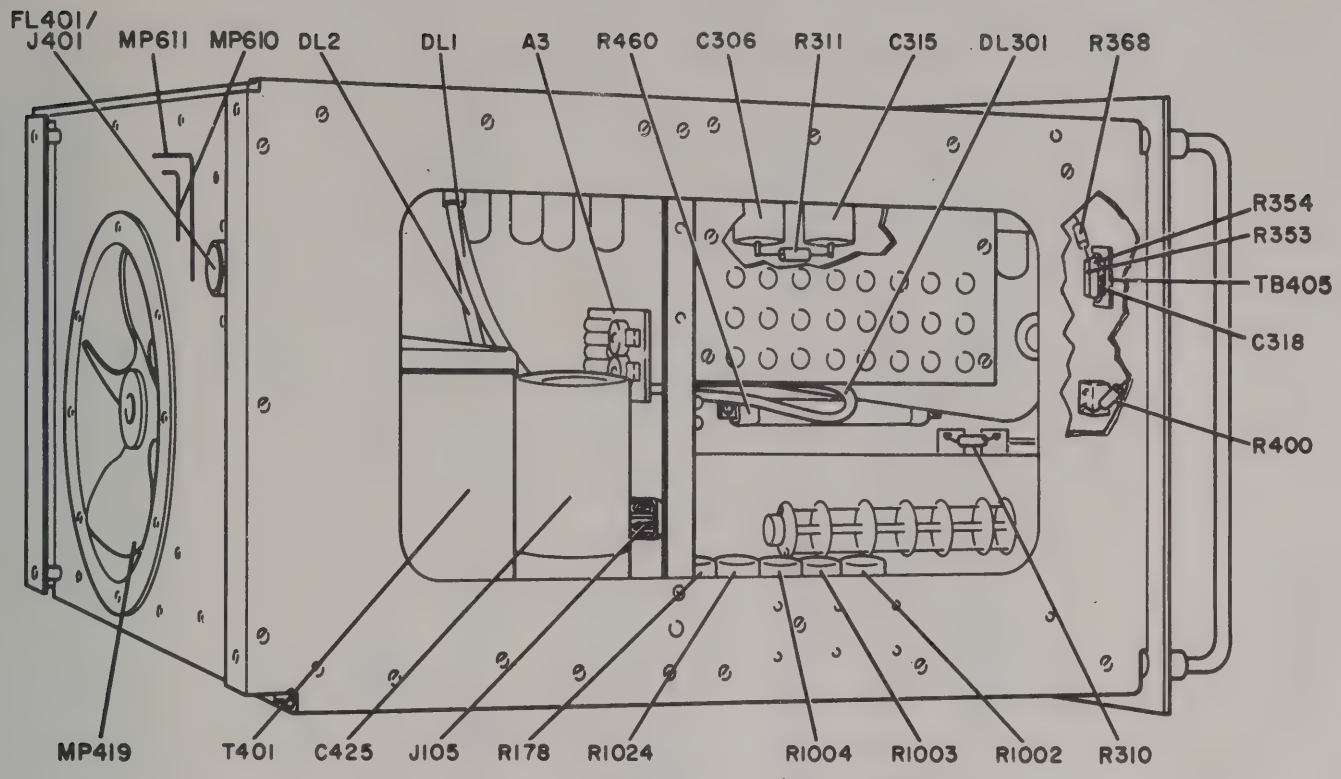


Figure 5-12. Left-Side View, Location of Parts

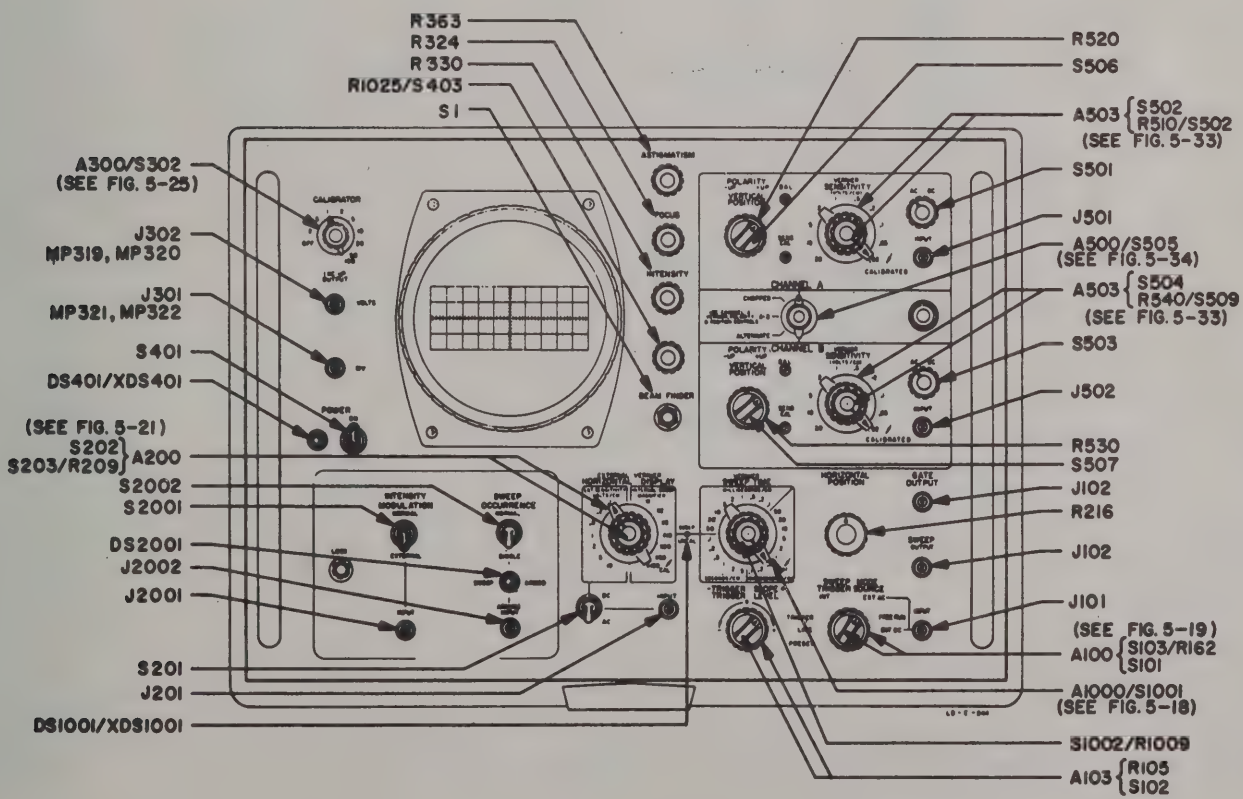


Figure 5-13. Front-View, Location of Parts

PARTS LOCATION INDEX FOR FIGURE 5-14

REF. DESIG.	DRAWING LOCATION
C1	B2
C2	B3
C7	D5
C8	C5
C9	D6
C10	C6
C11	B5
C12	B6
C13	A6
C14	B5
C15	B4
L3	B4
L4	B4
L5	C4
L6	C4
L9	C6
L10	A6
R1	B2
R2	A2
R3	C2
R4	C2
R5	A3
R6	B2
R7	D3
R8	A3
R9	D2
R11	B4
R12	A4

REF. DESIG.	DRAWING LOCATION
R14	C3
R16	C4
R18	C5
R19	C4
R20	B5
R21	C6
R22	D6
R23	D6
R24	C5
R25	B6
R26	B5
R27	B5
R28	B5
R29	A6
R30	A6
R31	A5
R32	B6
R36	B3
R37	D4
R39	A4
R40	D5
R41	A5
XV1	B2
XV2	B3
XV3	C3
XV4	C5
XV5	A5

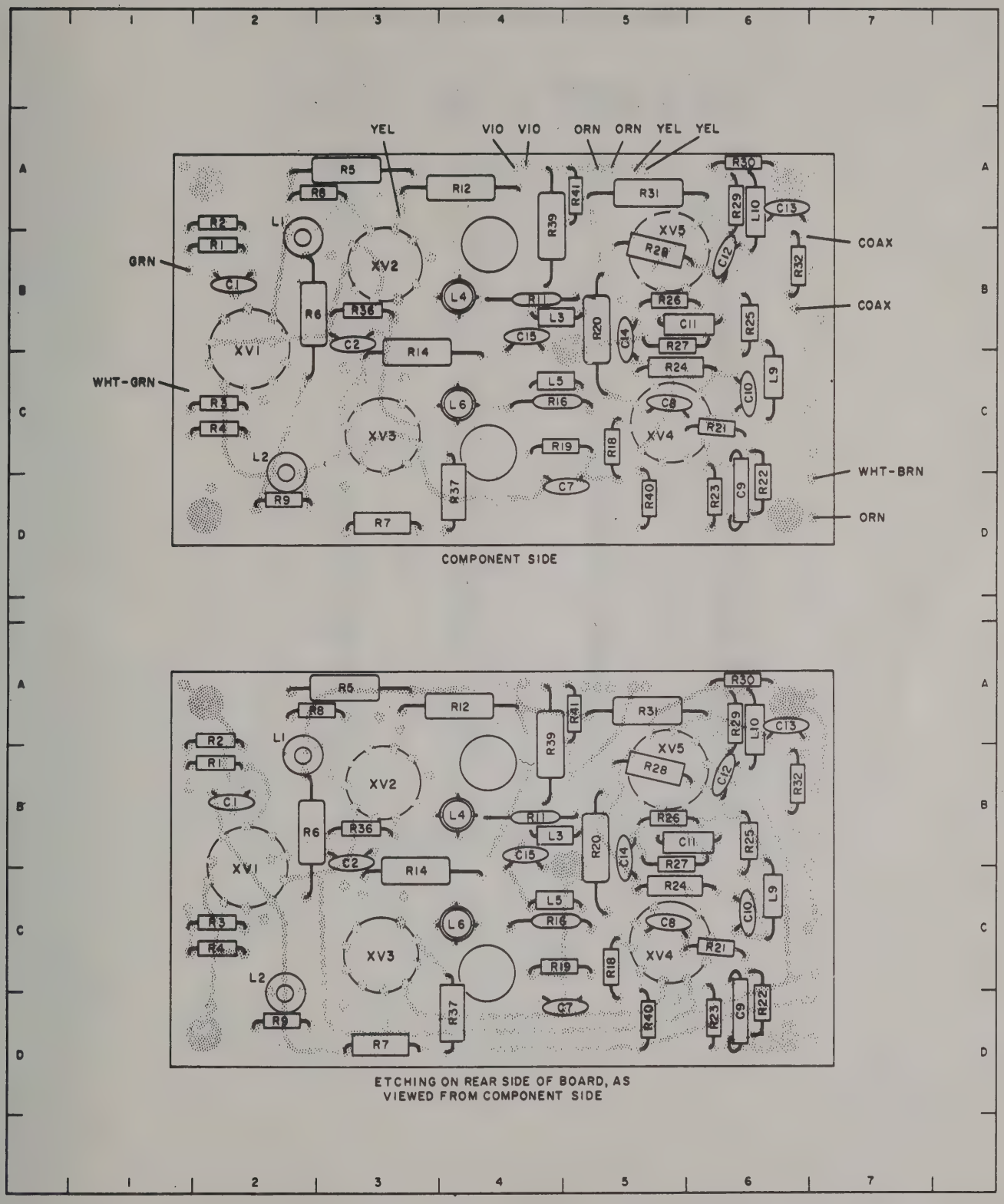


Figure 5-14. Main Vertical Input Amplifier and Internal Sync Source Etched Circuit Assembly, Location of Parts

PARTS LOCATION INDEX FOR FIGURE 5-15

REF. DESIG.	DRAWING LOCATION
C20	B4
C21	A2
C22	C4
C23	C4
C24	C4
C25	B4
C26	C1
C27	B4
C30	D6
C31	D5
C32	C5
C33	A5
C34	B7
C35	B4
L13	D2
L14	D3
L15	D4
L16	A2
L17	A2
L18	B4
L19	C4
L20	B4
L21	A5
L22	A6
R45	D2
R46	D3
R47	D4
R48	C4
R49	B3
R50	C3
R51	C3
R52	C3
R53	C5
R54	B2
R55	B2

REF. DESIG.	DRAWING LOCATION
R56	D2
R62	B2
R63	B3
R64	C4
R65	A3
R66	B3
R67	B3
R68	B3
R69	B4
R70	B2
R71	B2
R77	C5
R78	C5
R79	C5
R80	B5
R83	C6
R84	C6
R85	B6
R86	B6
R89	B5
R90	A5
R91	B5
R92	B6
R93	A6
R94	B6
R97	B7
R98	A7
V8	C4
V9	C4
XV6	C4
XV7	C2
XV10	C6
XV11	C5
XV12	B5
XV13	B6

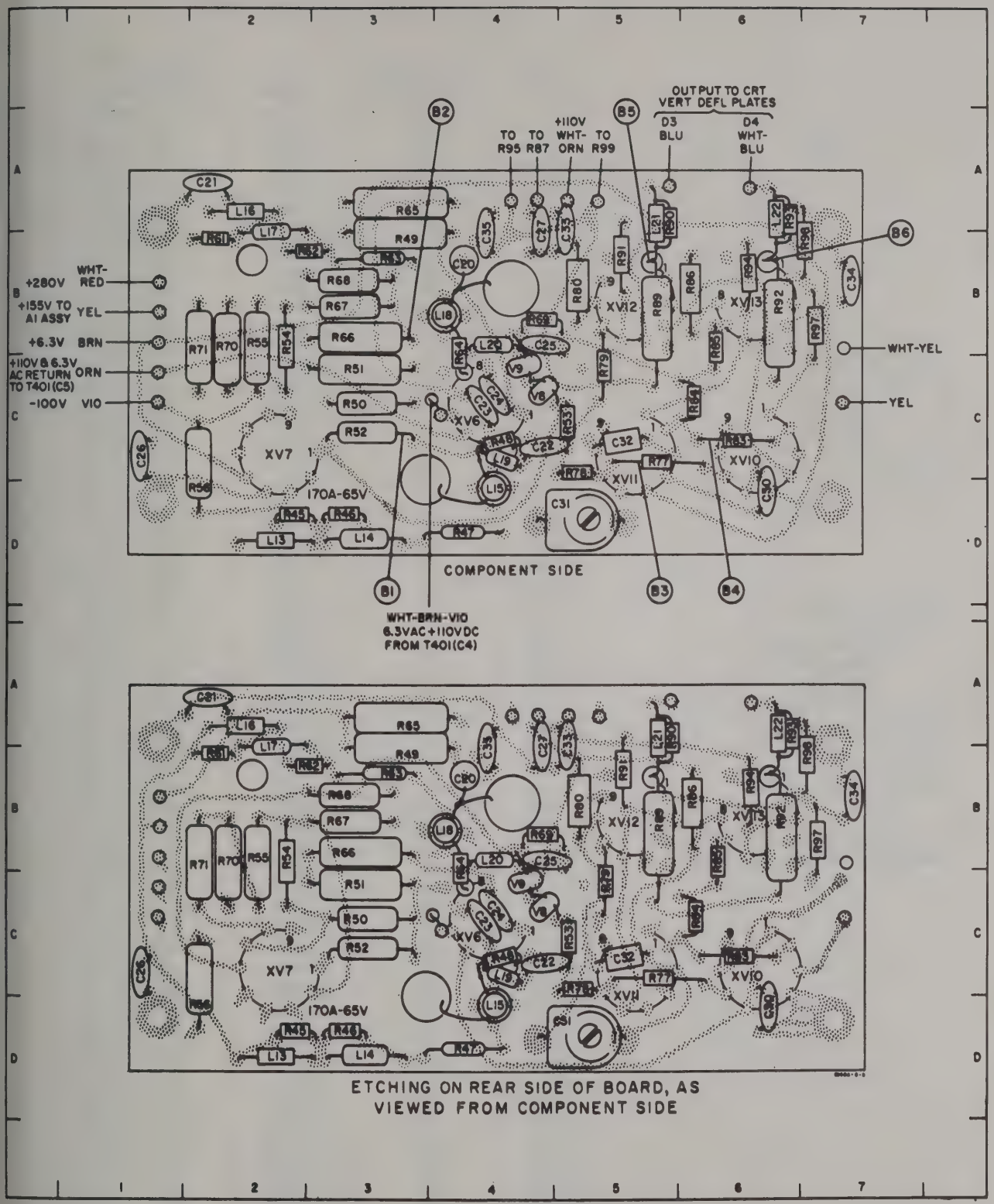


Figure 5-15. Main Vertical Amplifier and Driver Etched Circuit Assembly, Location of Parts

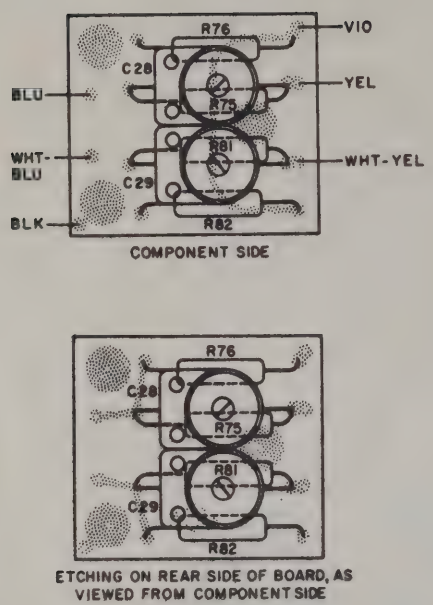


Figure 5-16. Scanner Output Etched Circuit Assembly, Location of Parts

PARTS LOCATION INDEX FOR FIGURE 5-17

REF. DESIG.	DRAWING LOCATION
CR101	B3
CR102	B3
CR103	A4
CR104	A5
C102	C6
C105	C2
C106	B2
C107	B2
C108	B2
C109	A3
C110	A2
C114	A4
C116	C4
C117	B3
C118	C3
C119	B5
C121	B6
C122	A6
C123	C6
C124	B6
C132	D3
C133	C3
C134	C5
C135	B5
C136	C3
C137	C4
C138	C3
C139	C3
C140	A6
C141	A6
C142	B4
C143	D5
L101	B2
L102	A2
L103	B3
R107	C2
R108	C2
R109	B2
R110	C2
R111	D2
R112	D2
R113	D2
R115	A2
R116	A2
R117	B2
R118	B2
R119	B2
R120	B2
R121	B3
R122	B3
R123	A3
R124	B3
R125	B3
R130	A3
R131	B4
R132	B4
R133	D5
R135	B4
R136	C4

REF. DESIG.	DRAWING LOCATION
R137	C4
R138	C4
R139	B3
R140	A3
R141	A3
R142	B3
R143	C2
R144	A4
R145	B4
R146	A5
R147	A5
R148	B5
R149	B5
R150	B5
R151	B5
R152	B6
R153	A5
R154	C6
R155	C6
R156	C5
R157	C6
R158	B5
R159	B6
R160	B6
R165	D4
R167	C3
R168	D3
R169	C3
R170	C3
R171	D4
R172	C3
R173	C4
R174	D3
R175	C5
R176	D5
R177	D5
R179	D5
R180	B5
R181	C5
R182	B5
R186	C5
R187	C3
R188	A5
R189	B6
R190	B4
V102	C2
V110	B2
V111	A4
V116	C6
XV101	C2
XV103	A2
XV104	A3
XV105	A5
XV107	C4
XV109	B6
XV113	C3
XV114	C5
XV115	C6

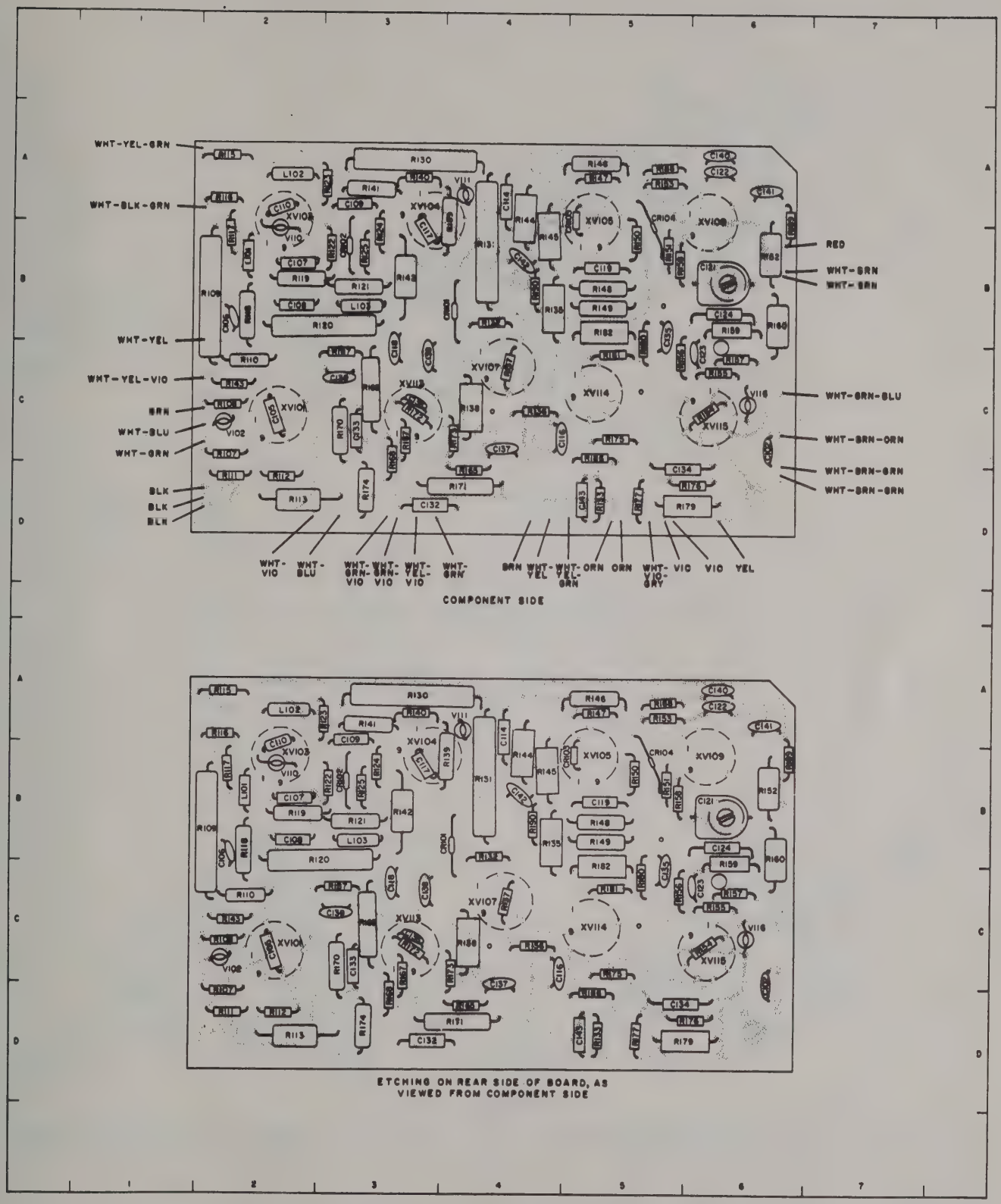


Figure 5-17. Sweep Generator Etched Circuit Assembly, Location of Parts

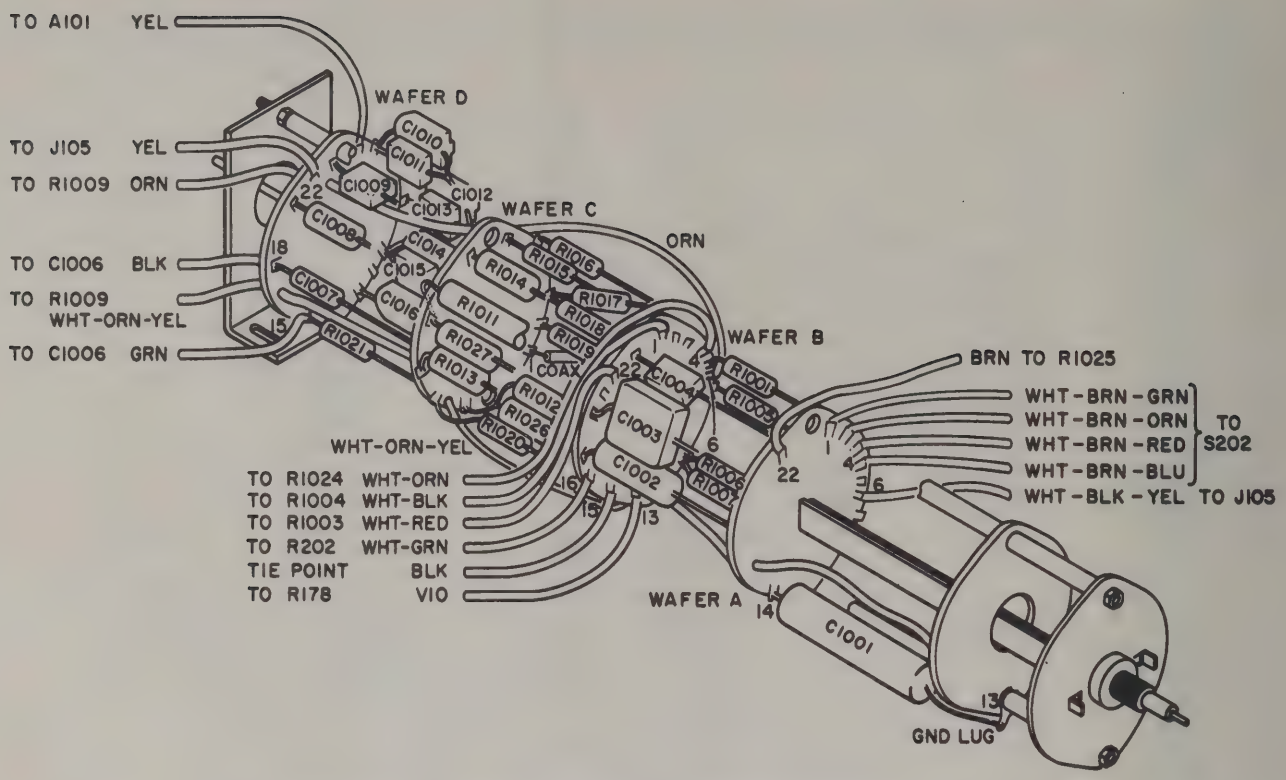


Figure 5-18. Sweep Time Switch Assembly, Location of Parts

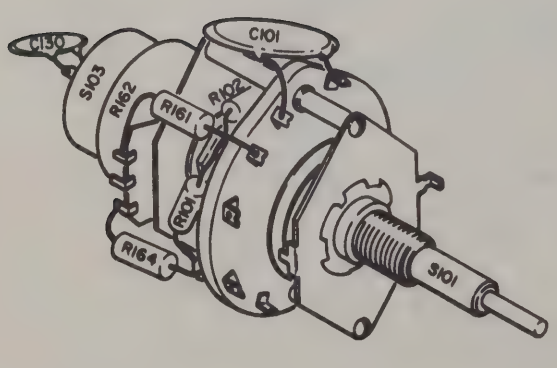


Figure 5-19. Sweep Mode/Trigger Source Switch Assembly, Location of Parts

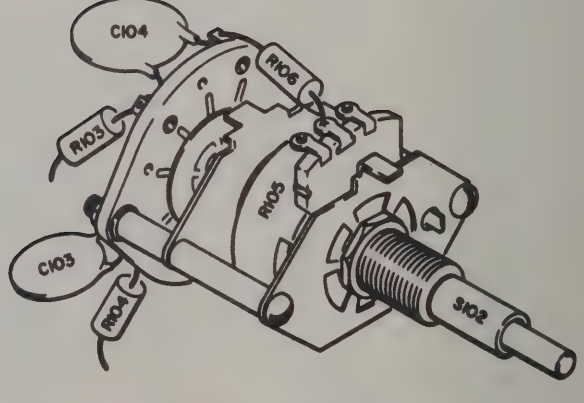


Figure 5-20. Trigger Level/Trigger Slope Switch Assembly, Location of Parts

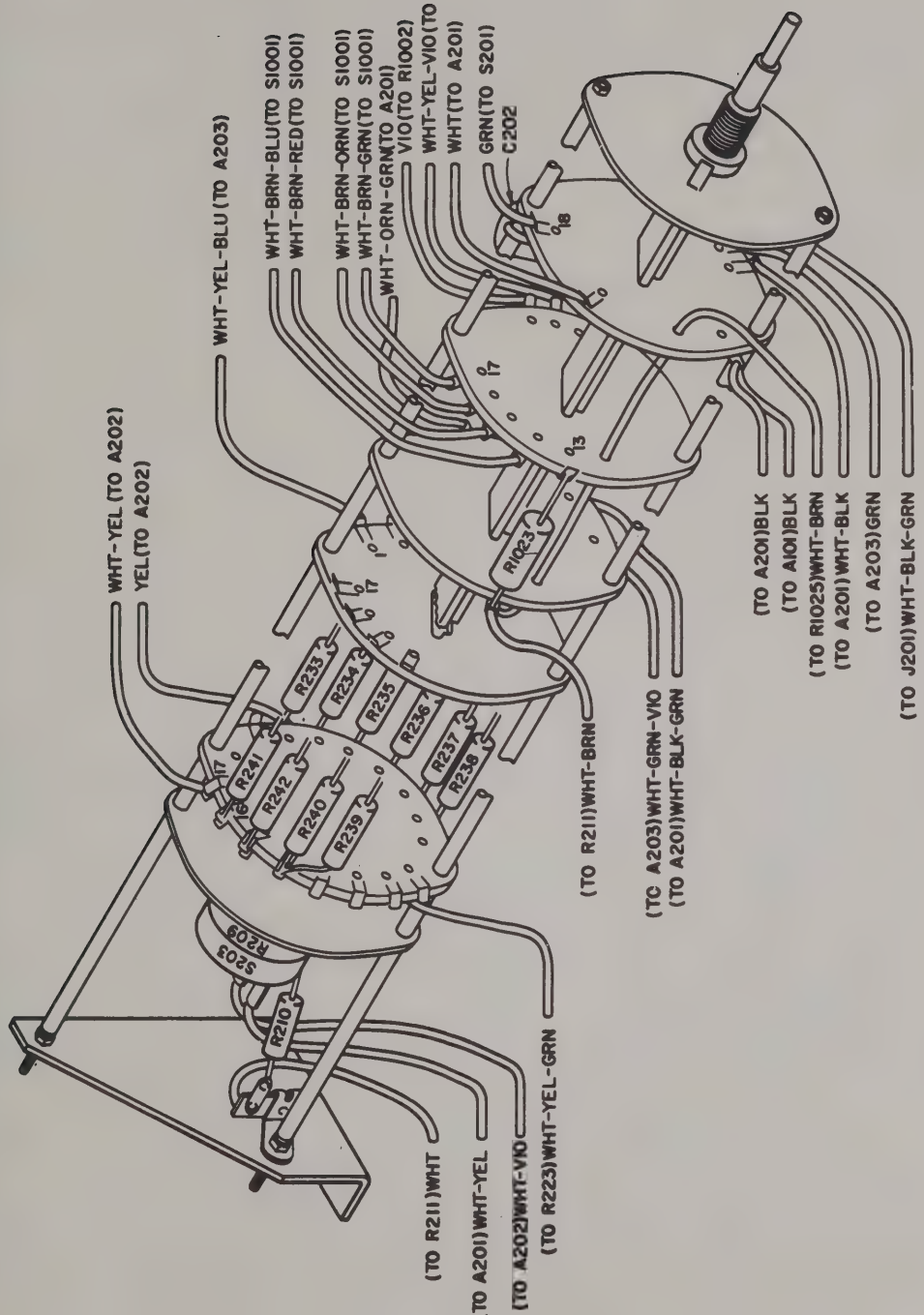
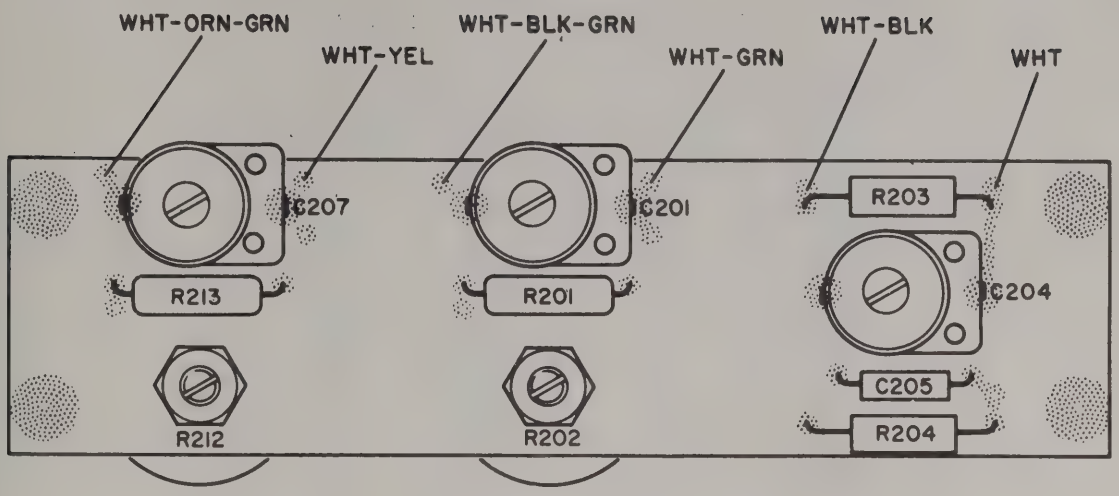
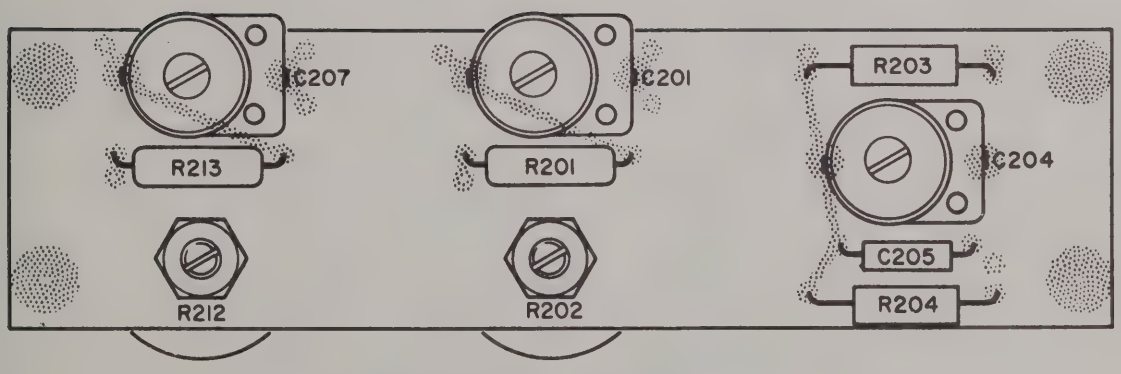


Figure 5-21. Ext. Vernier/Horizontal Display Switch Assembly, Location of Parts



COMPONENT SIDE



ETCHING ON REAR SIDE OF BOARD,
AS VIEWED FROM COMPONENT SIDE

Figure 5-22. Horizontal Sensitivity Adjustment Etched Circuit Assembly, Location of Parts

PARTS LOCATION INDEX FOR FIGURE 5-23

REF. DESIG.	DRAWING LOCATION
C211	A2
C212	A3
C213	C3
C214	D3
C215	A6
C216	A6
C222	C6
L201	A4
L202	D4
Q201	A3
Q202	C2
R244	A2
R245	A3
R246	A3
R247	B3
R248	B3
R249	B3
R250	B3
R251	B3
R252	C3
R253	B3
R254	C3
R255	A3

REF. DESIG.	DRAWING LOCATION
R256	A3
R257	C4
R258	C3
R259	D2
R260	D4
R264	B5
R266	A4
R267	B4
R268	A4
R269	C4
R271	A5
R272	A5
R273	C5
R274	C5
R275	C5
R276	C5
R278	A5
XV203	B4
XV204	A3
XV205	C3
XV206	B5
XV207	A5

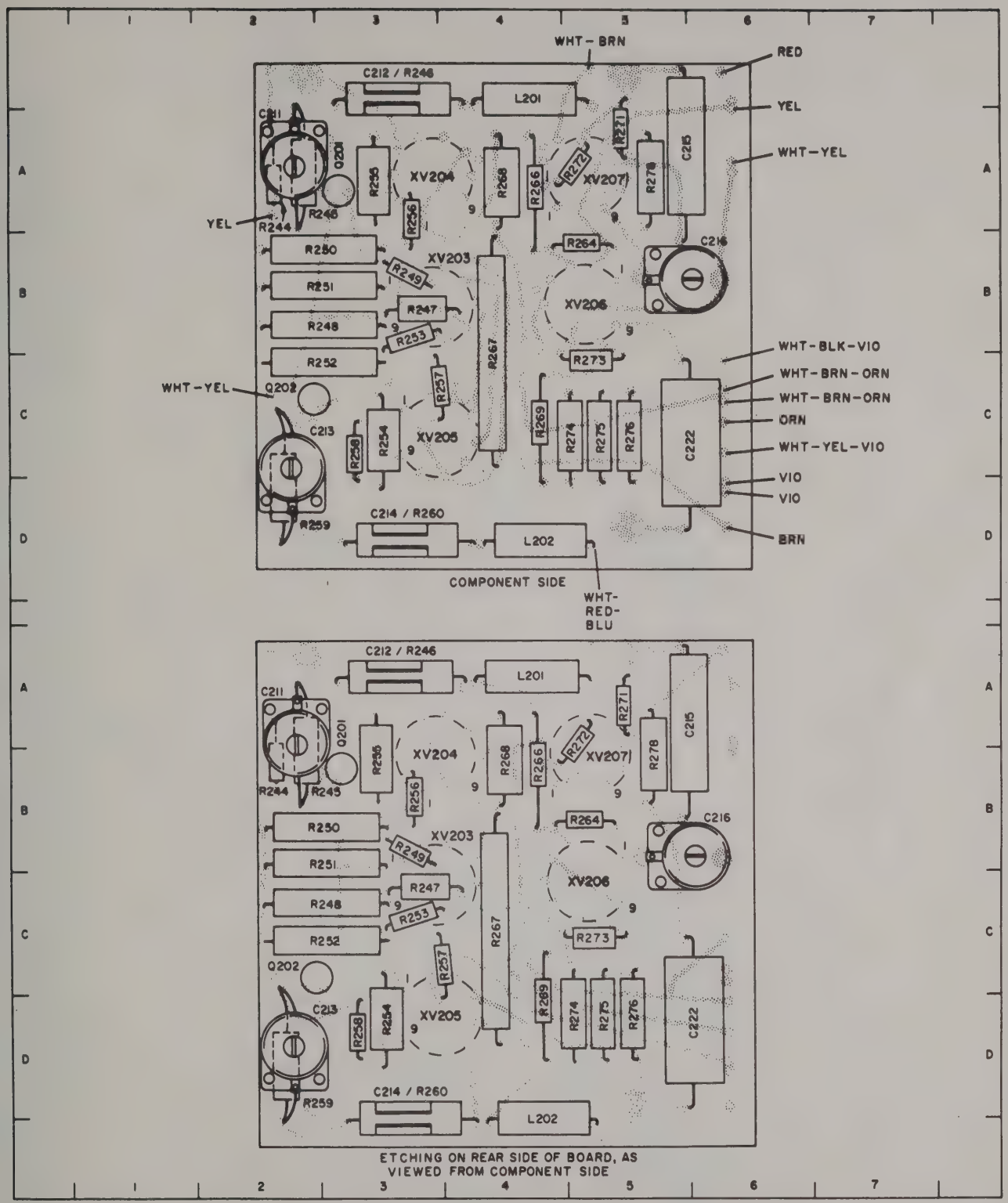


Figure 5-23. Main Horizontal Amplifier and Driver Etched Circuit Assembly, Location of Parts

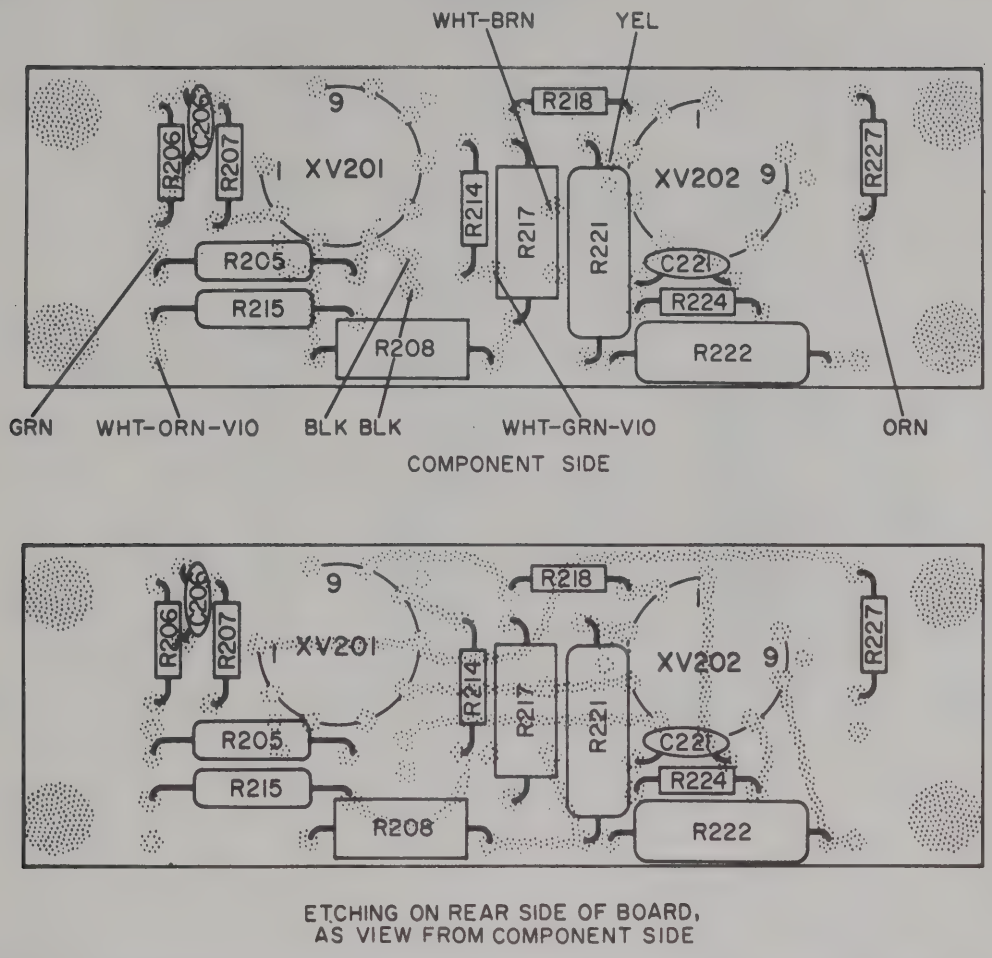


Figure 5-24. Horizontal Impedance Matching Previous Etched Circuit Assembly, Location of Parts

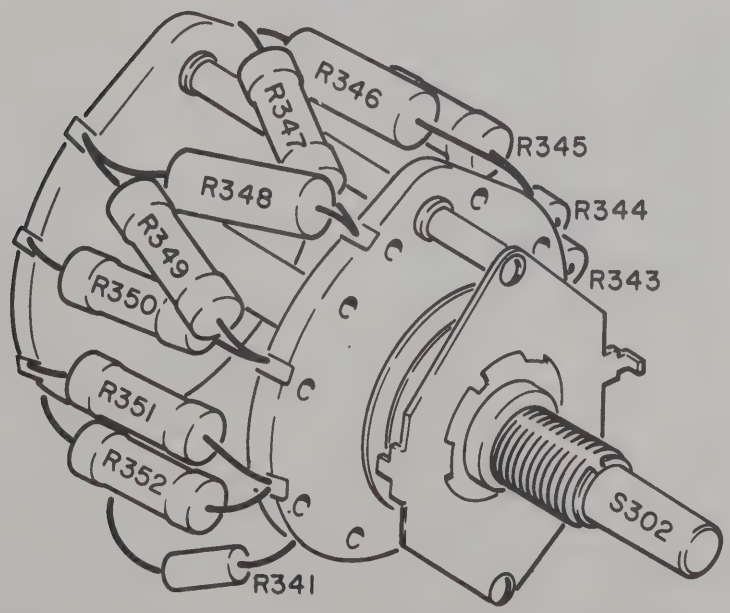


Figure 5-25. Calibrator Switch Assembly, Location of Parts

PARTS LOCATION INDEX FOR FIGURE 5-26

REF. DESIG.	DRAWING LOCATION
C301	D5
C302	B5
C303	B4
C304	A3
C310	B2
C316	C7
C317	C6
L301	C5
R302	B5
R303	C5
R304	C5
R305	B5
R306	C5
R308	B4
R309	B4
R312	A2
R319	B5

REF. DESIG.	DRAWING LOCATION
R335	B7
R336	B6
R337	D6
R338	B7
R339	C7
R340	D7
R342	C6
R367	B6
V303	C5
XV301	C5
XV304	B5
XV306	C7
XV307	B7
XV308	B1
XV309	C1
XV310	C3
XV311	C4

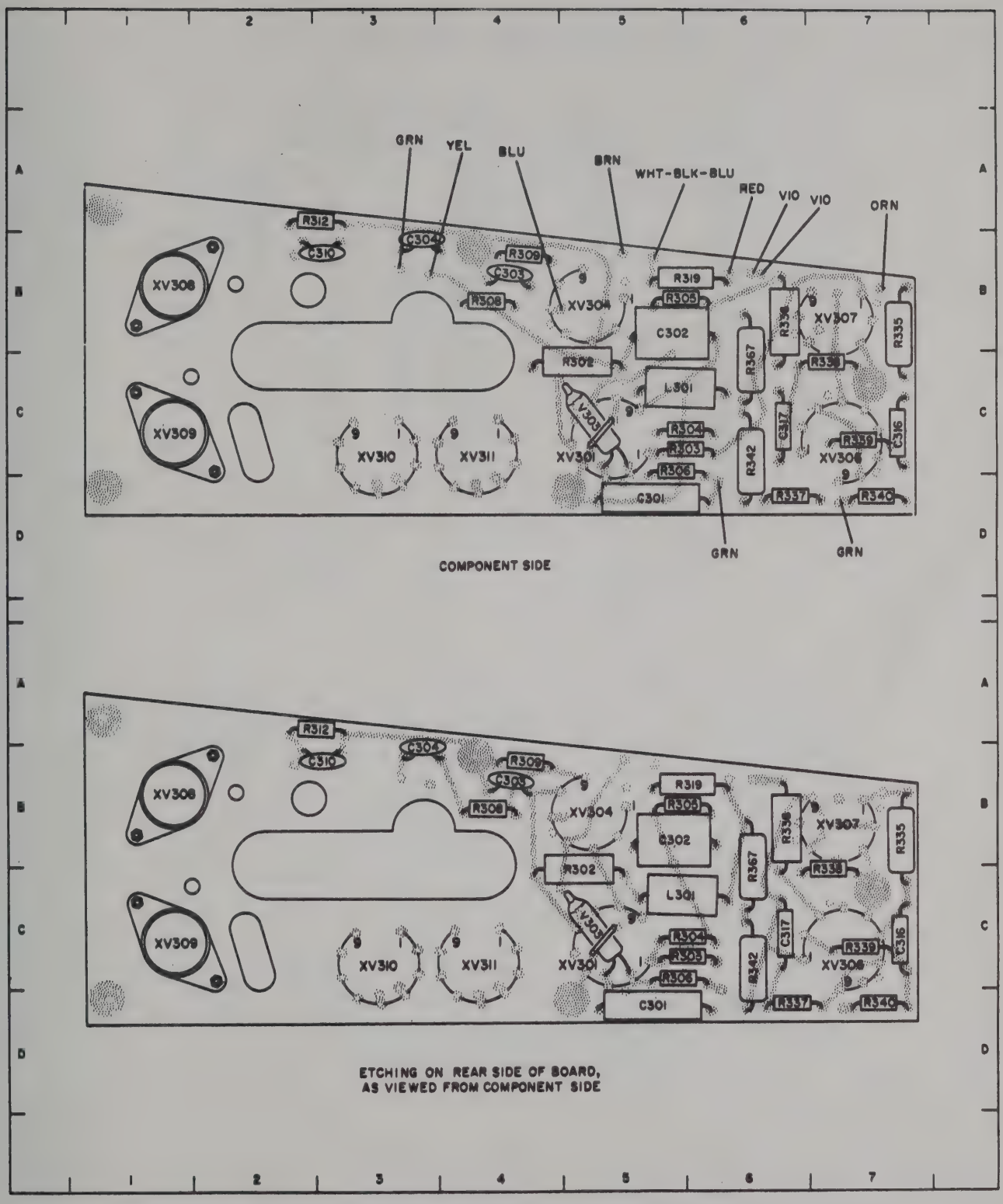


Figure 5-26. High-Voltage Power Supply Etched Circuit Assembly, Location of Parts

PARTS LOCATION INDEX FOR FIGURE 5-27

REF. DESIG.	DRAWING LOCATION
C307	B4
C308	C2
C309	C6
C311	B5
C312	B2
C313	C5
C314	A2
R313	B7
R314	B7
R315	C7
R316	B6
R317	B6
R318	B6
R322	C3
R323	C4
R325	D3
R326	D5

REF. DESIG.	DRAWING LOCATION
R327	D6
R328	D5
R331	C1
R332	D2
R333	B1
R334	B1
R355	B2
R356	A2
R357	A5
R358	B3
R359	B3
R360	A4
R362	A3
R364	B2
R365	B3
R366	B3

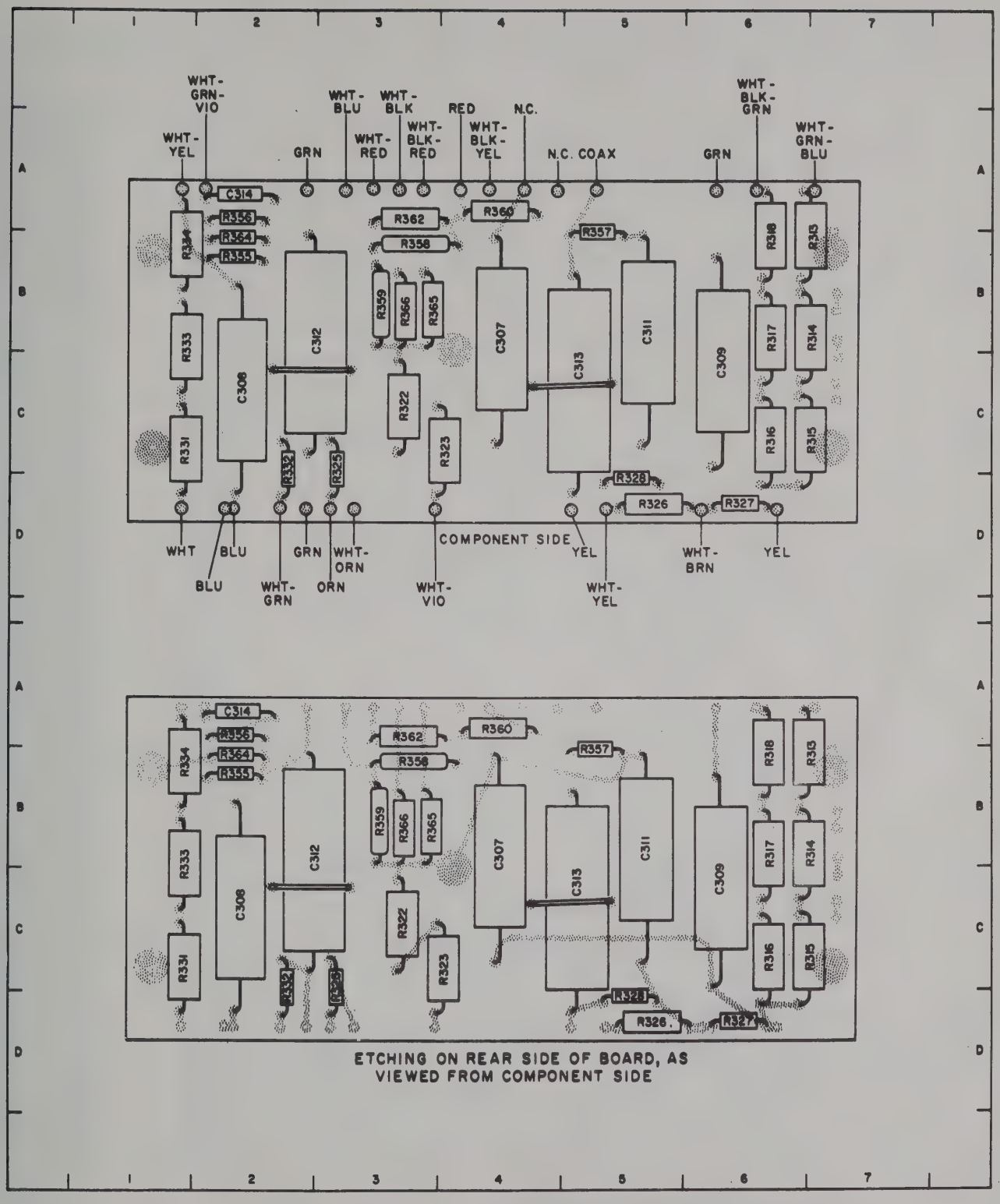
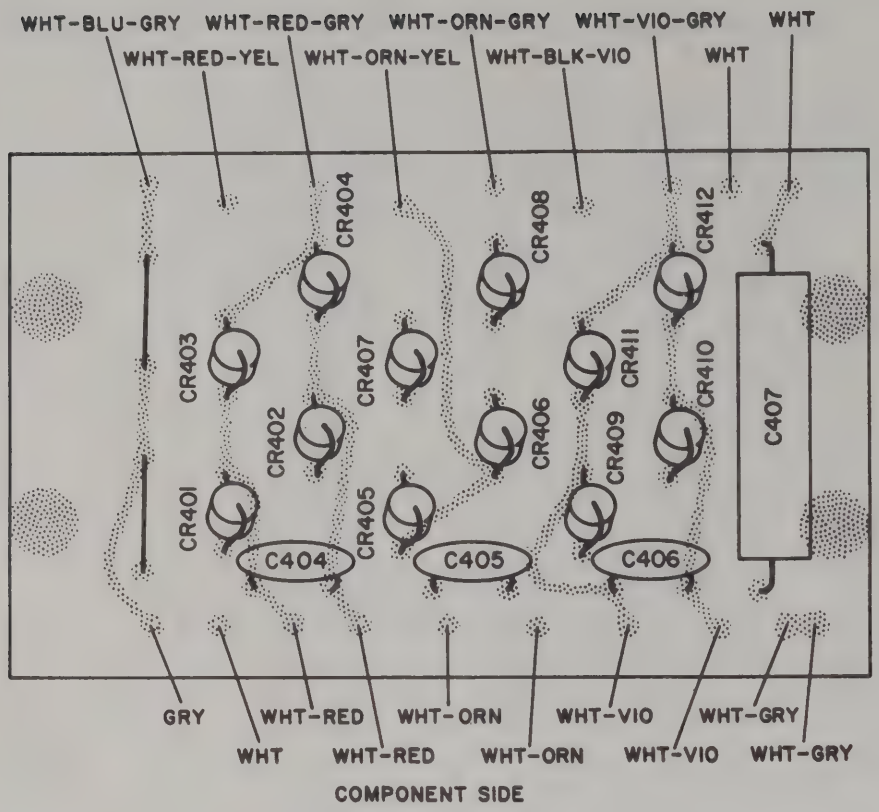
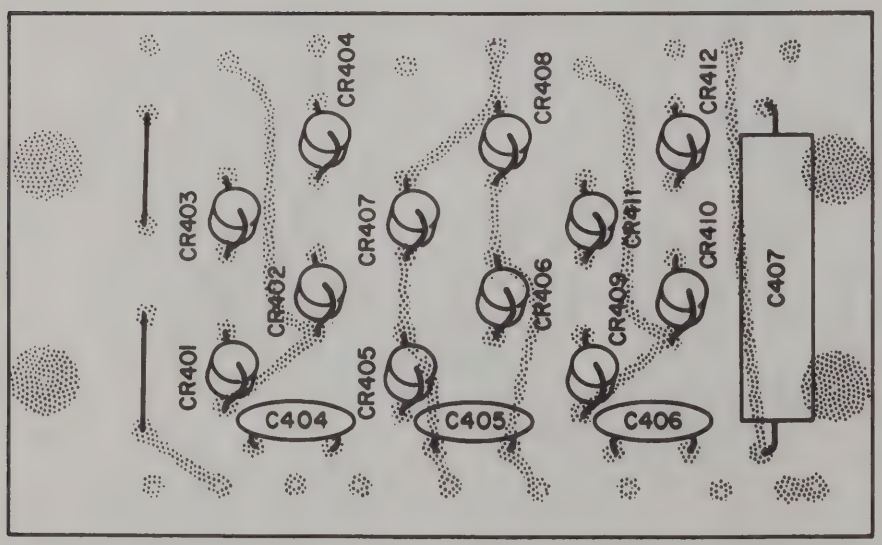


Figure 5-27. High-Voltage Distribution Etched Circuit Assembly, Location of Parts





ETCHING ON REAR SIDE OF BOARD,
AS VIEWED FROM COMPONENT SIDE

Figure 5-28. Low-Voltage Rectifier Etched Circuit Assembly, Location of Parts

PARTS LOCATION INDEX
FOR FIGURE 5-29

REF. DESIG.	DRAWING LOCATION
CR413	B5
CR416	B3
C409	A4
C412	C3
C413	B5
C417	A5
C418	C6
C419	C5
C426	A2
Q401	D3
Q402	B3
Q406	C5
Q407	C4
Q408	B5
Q410	B6
Q411	B6
Q412	B6
Q414	B3
Q415	B2
R408	C2
R409	D4
R410	D2
R412	B2
R413	D3
R415	C2
R416	C4
R417	C2
R425	A4
R426	A4
R427	C5
R428	D4
R430	D5
R432	C4
R433	C5
R434	C4
R435	C4
R443	A6
R444	A6
R445	B6
R446	A5
R447	B5
R448	C6
R449	B5
R450	C6
R451	D6
R459	A3
R461	B3
R462	B3
R463	C2
XV401	C6

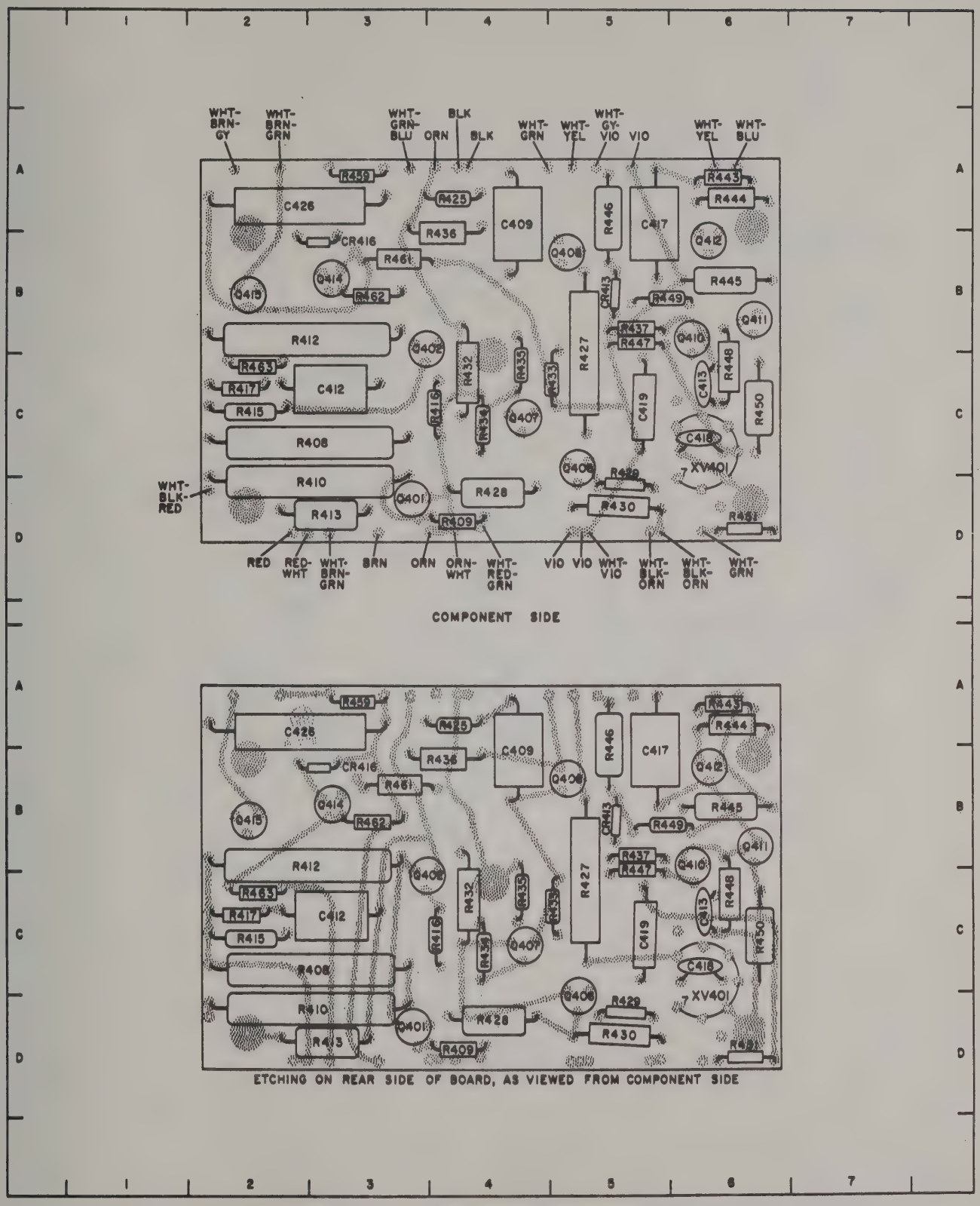


Figure 5-29. Low-Voltage Regulator Amplifier Etched Circuit Assembly, Location of Parts

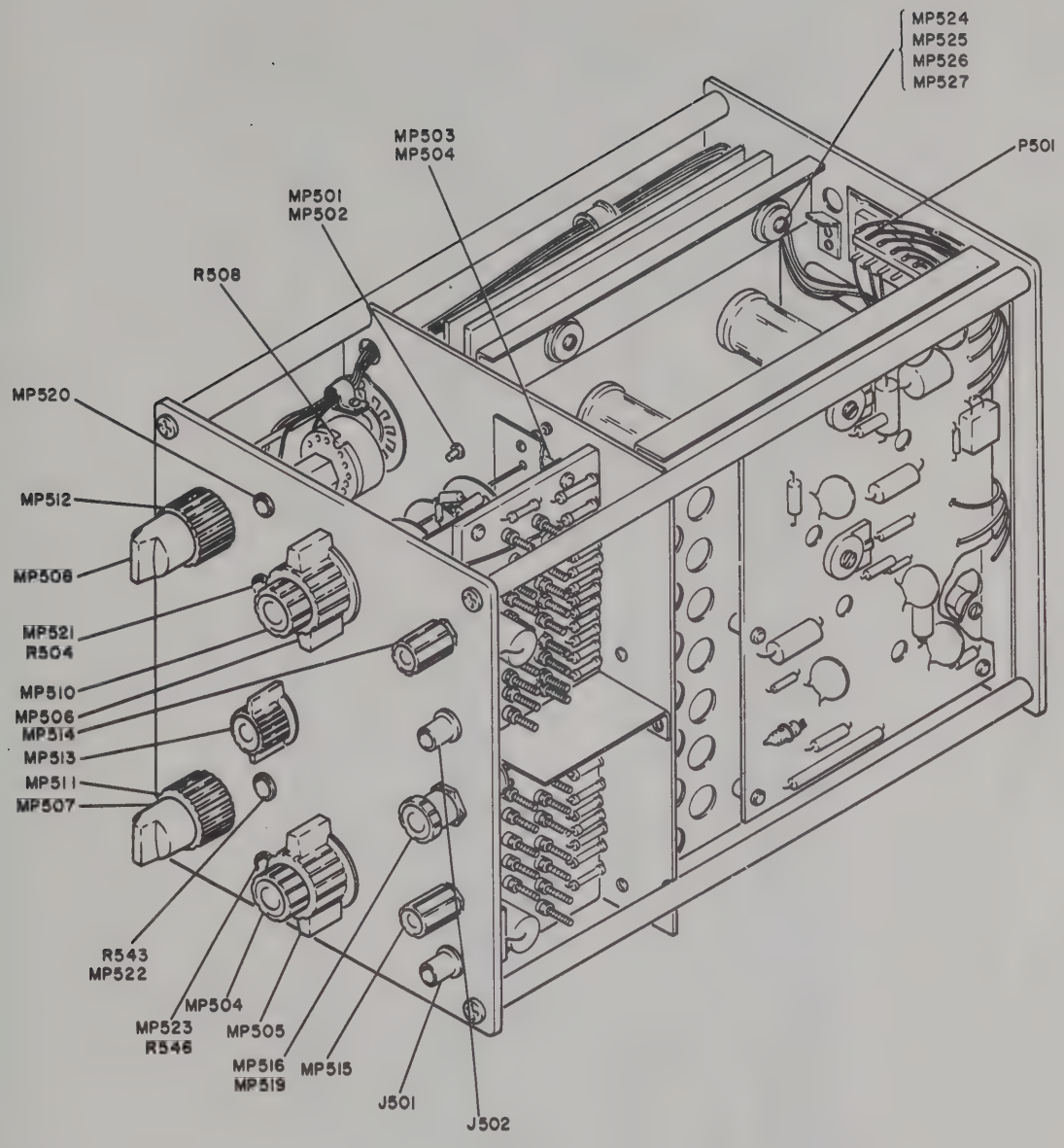


Figure 5-30. MX-2930B/USM, Location of Parts

PARTS LOCATION INDEX FOR FIGURE 5-31

REF. DESIG.	DRAWING LOCATION
CR501	A3
CR505	D3
C503	B5
C504	A2
C516	B5
C517	C6
C518	B6
C522	B3
C523	C3
L501	B4
L502	A3
L503	B3
L505	A3
L508	C3
L510	C3
L511	C4
L512	C3
L514	B4
L515	A3
L516	B2
L517	C2
L518	C5
L519	C3
Q501	B4
Q502	A3
Q503	C4
Q504	D3
R501	B5
R502	B5
R503	B5
R505	A5
R507	A5
R509	A5
R512	A4
R513	A4
R514	B4
R515	A4
R516	B4
R517	A3
R519	A4
R521	A3
R522	A2
R523	C3

REF. DESIG.	DRAWING LOCATION
R524	B3
R527	B6
R528	A6
R529	D4
R531	D3
R532	C4
R533	D2
R534	C4
R535	C3
R536	D4
R537	C4
R538	D4
R539	D4
R542	D5
R544	D5
R545	D5
R547	C5
R548	C5
R549	C5
R550	D6
R552	C4
R571	B3
R572	A3
R573	C3
R574	C3
R575	C4
R580	C5
R581	B5
R582	B4
R583	B3
R584	B3
R585	C2
R586	B2
R587	C2
R588	C4
R589	C3
XV501	B5
XV502	A5
XV503	B3
XV504	C5
XV505	C5
XV506	C3

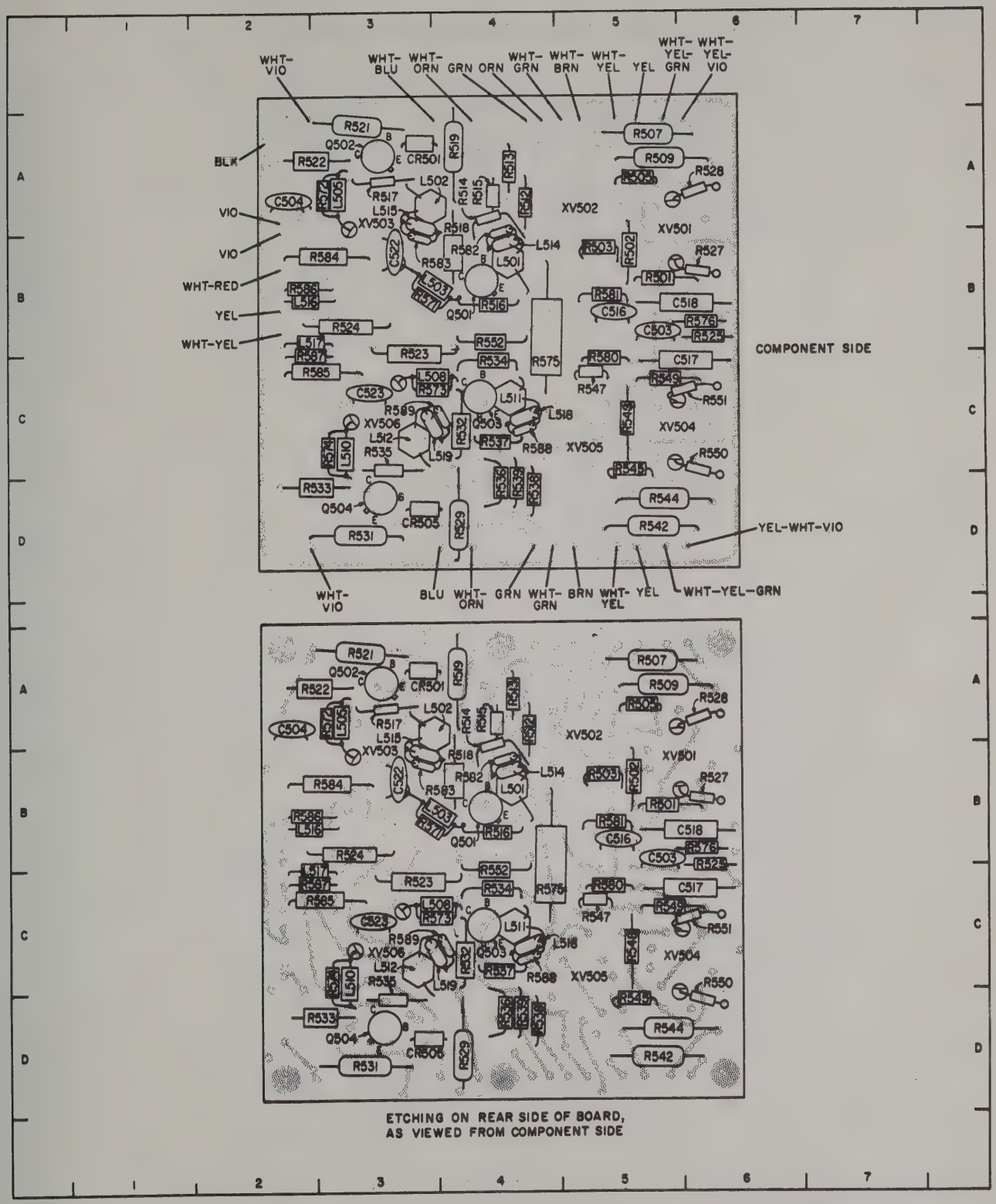


Figure 5-31. MX-2930B/USM Dual Channel Vertical Amplifier Etched Circuit Assembly, Location of Parts

PARTS LOCATION INDEX FOR FIGURE 5-32

REF. DESIG.	DRAWING LOCATION
CR502	B4
CR503	B4
CR504	D5
CR506	B4
C506	C5
C507	C3
C508	D5
C509	A3
C510	C4
C511	B3
C515	A4
C519	A5
L513	A4
R526	C3
R554	D4
R555	D5
R556	D3
R557	D3
R559	C4

REF. DESIG.	DRAWING LOCATION
R560	C5
R562	A4
R563	A3
R564	B4
R565	C4
R566	C4
R567	B3
R568	B3
R569	C3
R570	B4
R579	A4
R588	C4
R591	B5
R592	A5
R593	B5
T501	B5
V509	C3
XV507	D4
XV508	B4

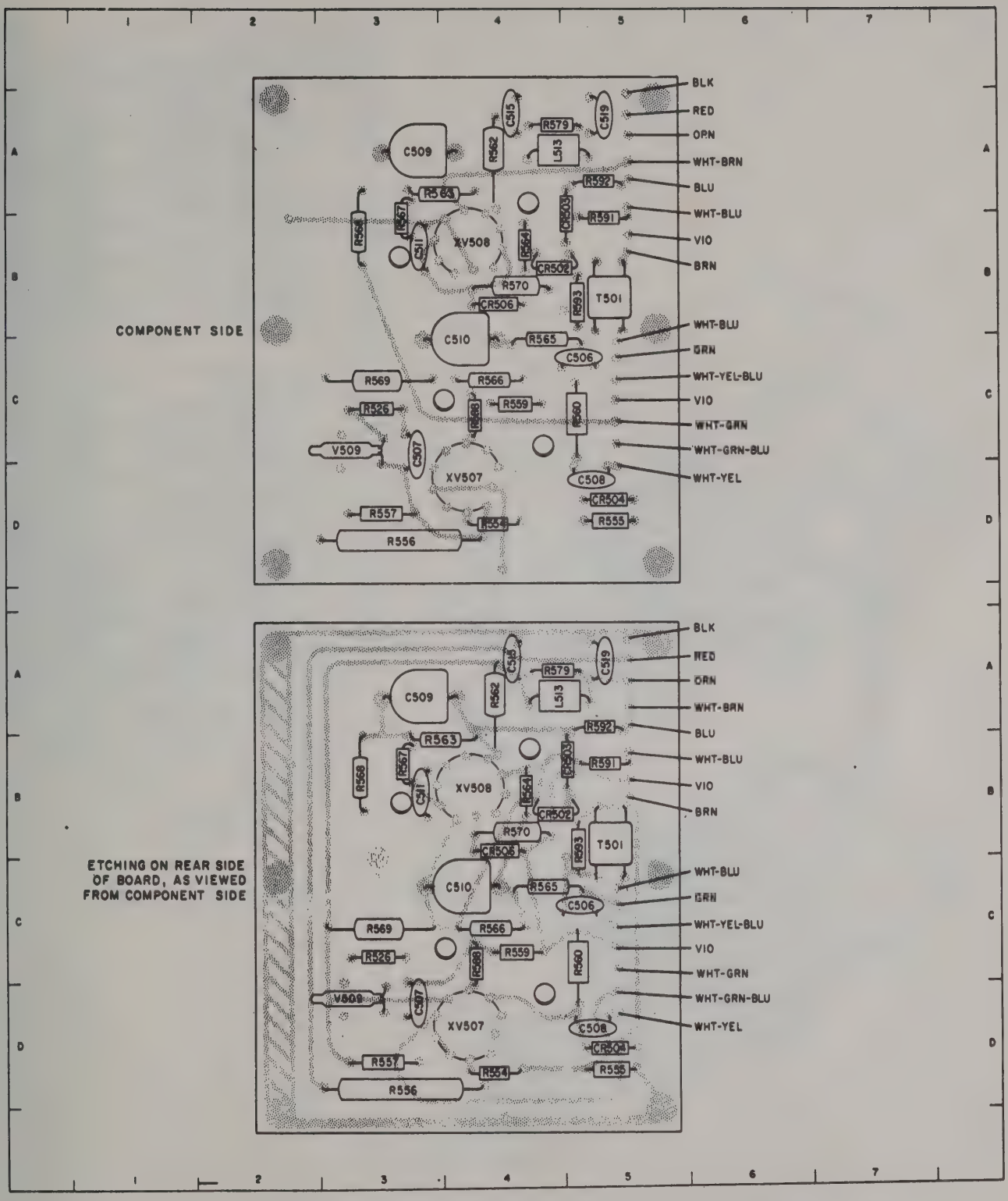


Figure 5-32. MX-2930B/USM Vertical Switching Etched Circuit Assembly, Location of Parts

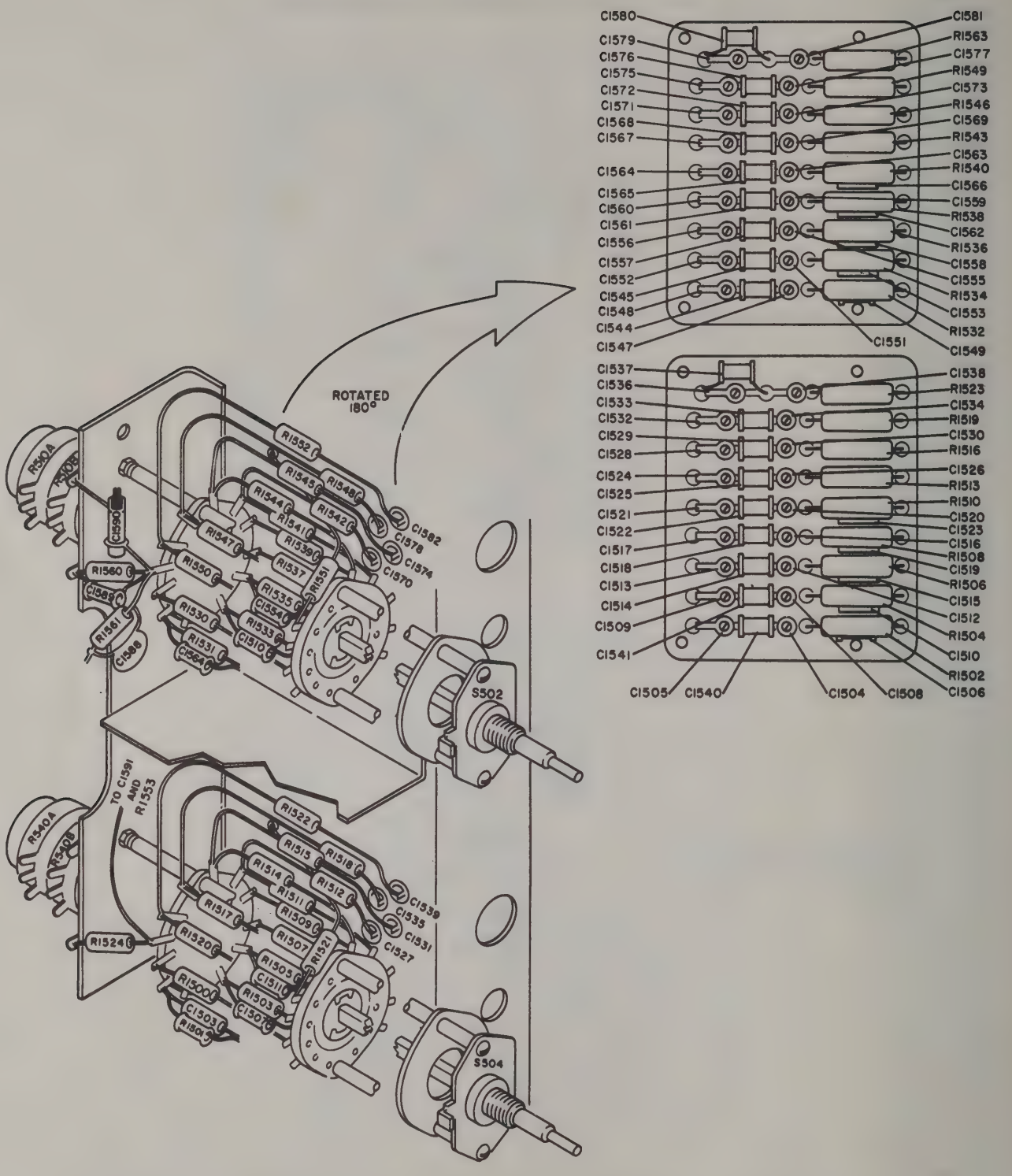


Figure 5-33. MX-2930B/USM Vernier/Sensitivity Switch Assembly, Location of Parts

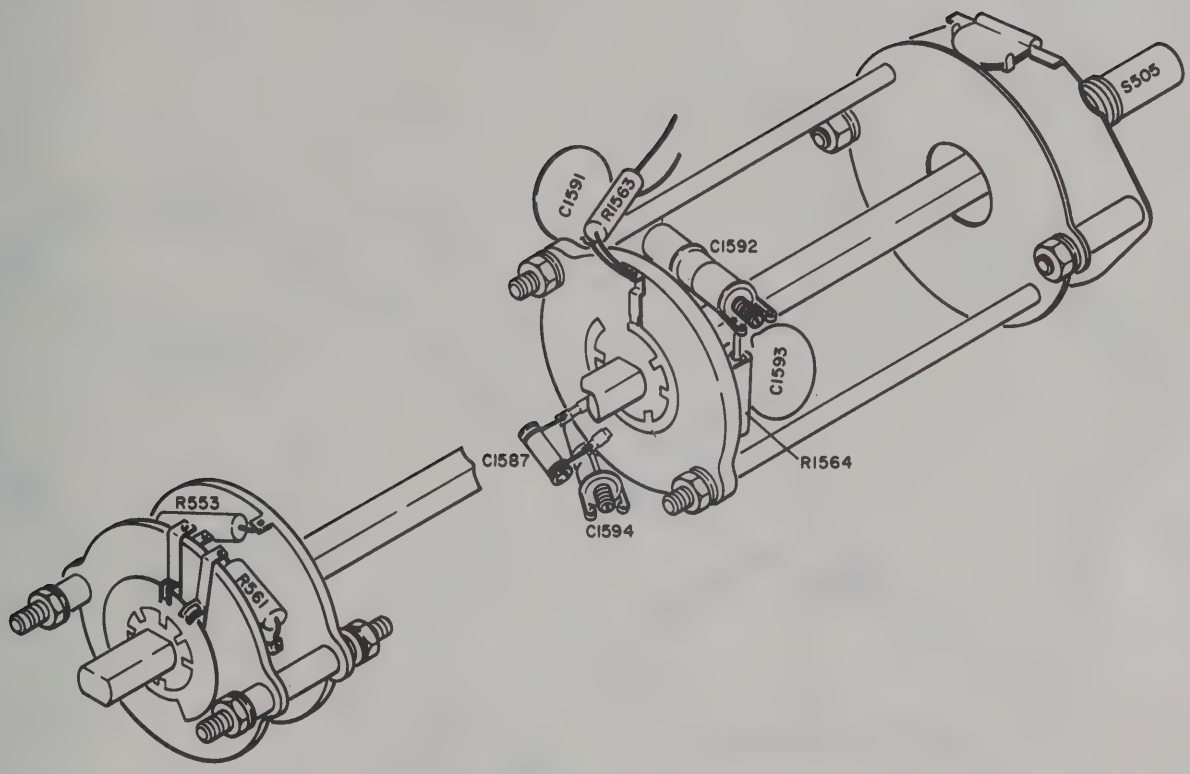


Figure 5-34. MX-2930B/USM Vertical Presentation Switch Assembly, Location of Parts

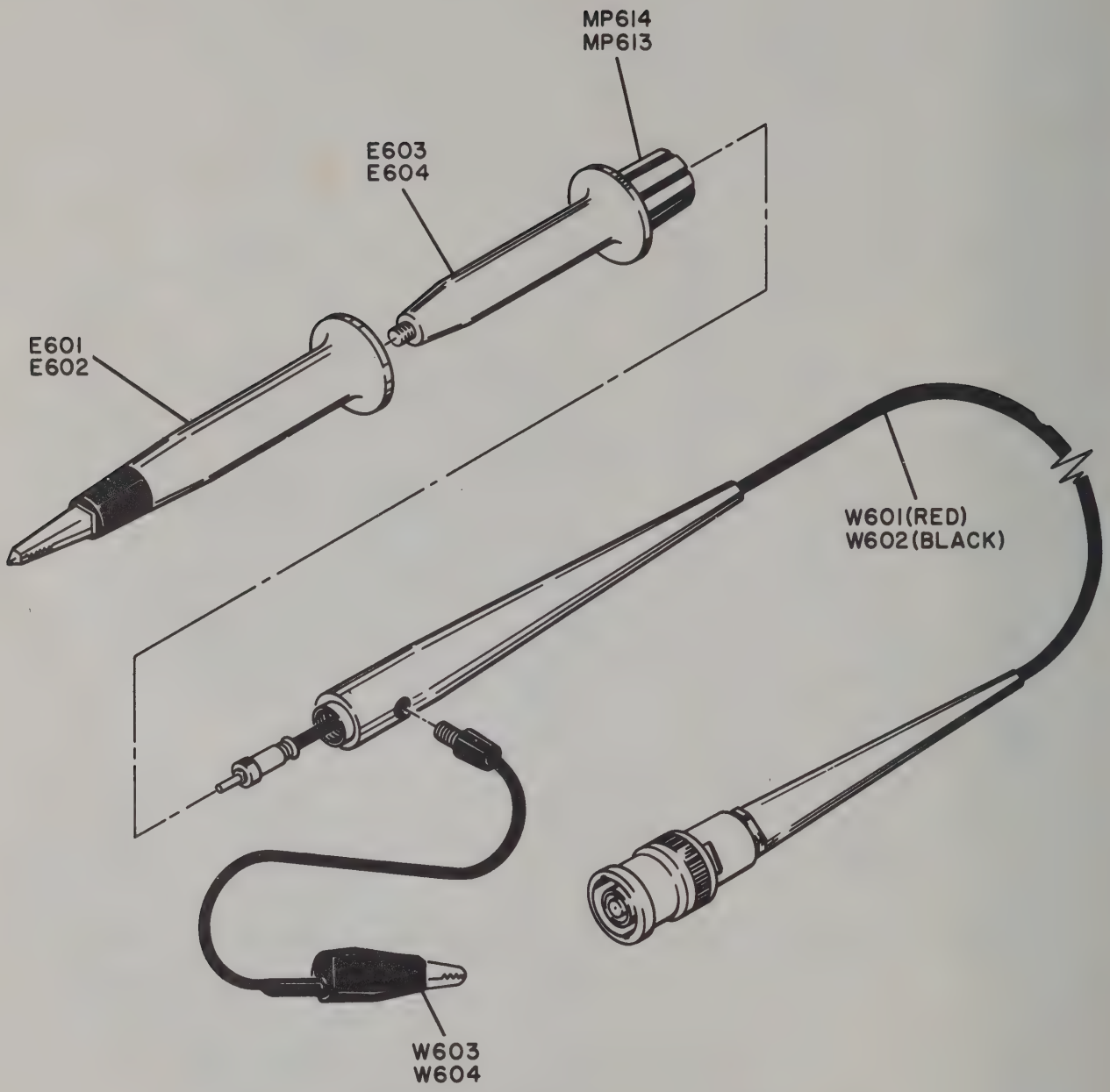


Figure 5-35. MX-2817/U Test Prod, Location of Replaceable Parts.

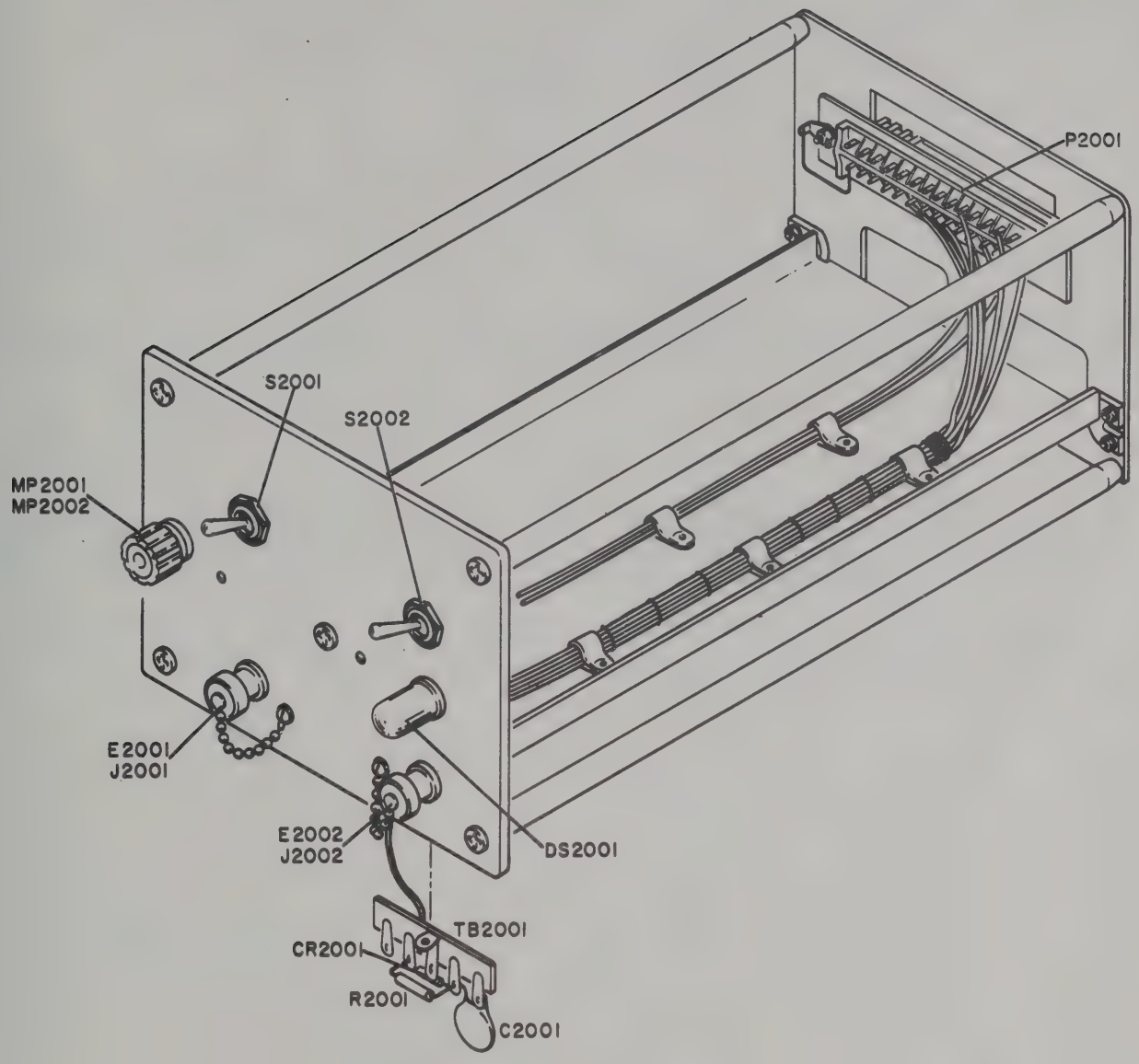


Figure 5-36. MX-3078/USM Horizontal Auxiliary Plug-In Unit, Location of Parts

TABLE 5-11. GENERAL SCHEMATIC DIAGRAM NOTES

1. Component values expressed in ohms, microhenries, and picofarads unless otherwise noted.
2. —— - - —— indicates etched circuit assembly boundaries.
3. Names of panel controls and connectors are enclosed in boxes.
4. Primary signal paths weighted. Feedback paths weighted and dashed.
5. DC voltages are preceded by "+" or "-". AC signal and ripple voltages are followed by VP-P.
6. The letters CW or CCW, placed adjacent to the appropriate terminals of a potentiometer, indicate the direction of rotation viewed from the shaft end.
7. AC signal and ripple voltages are measured with another AN/USM-140B Oscilloscope using the AM-3567/USM High Gain Differential Amplifier. An equivalent oscilloscope may be used. 400 cps sine waves are used for signal voltage measurements except where other waveforms are shown.
8. DC voltages are measured with the AN/USM-116 Voltmeter unless otherwise noted.
9. Special conditions or switch settings required for voltage measurements are noted on the schematics.
10. Because resistance measurements in circuits having many semiconductor elements can be misleading (see paragraph 5-5b)because they vary with the method of measurement, no tables of resistance values are given. Instead, a multiplicity of voltage test points is indicated, and additional voltages are provided in tables on the schematic aprons where necessary.
11. Parts location on each large schematic is given in a table of map-type coordinates on the schematic apron.

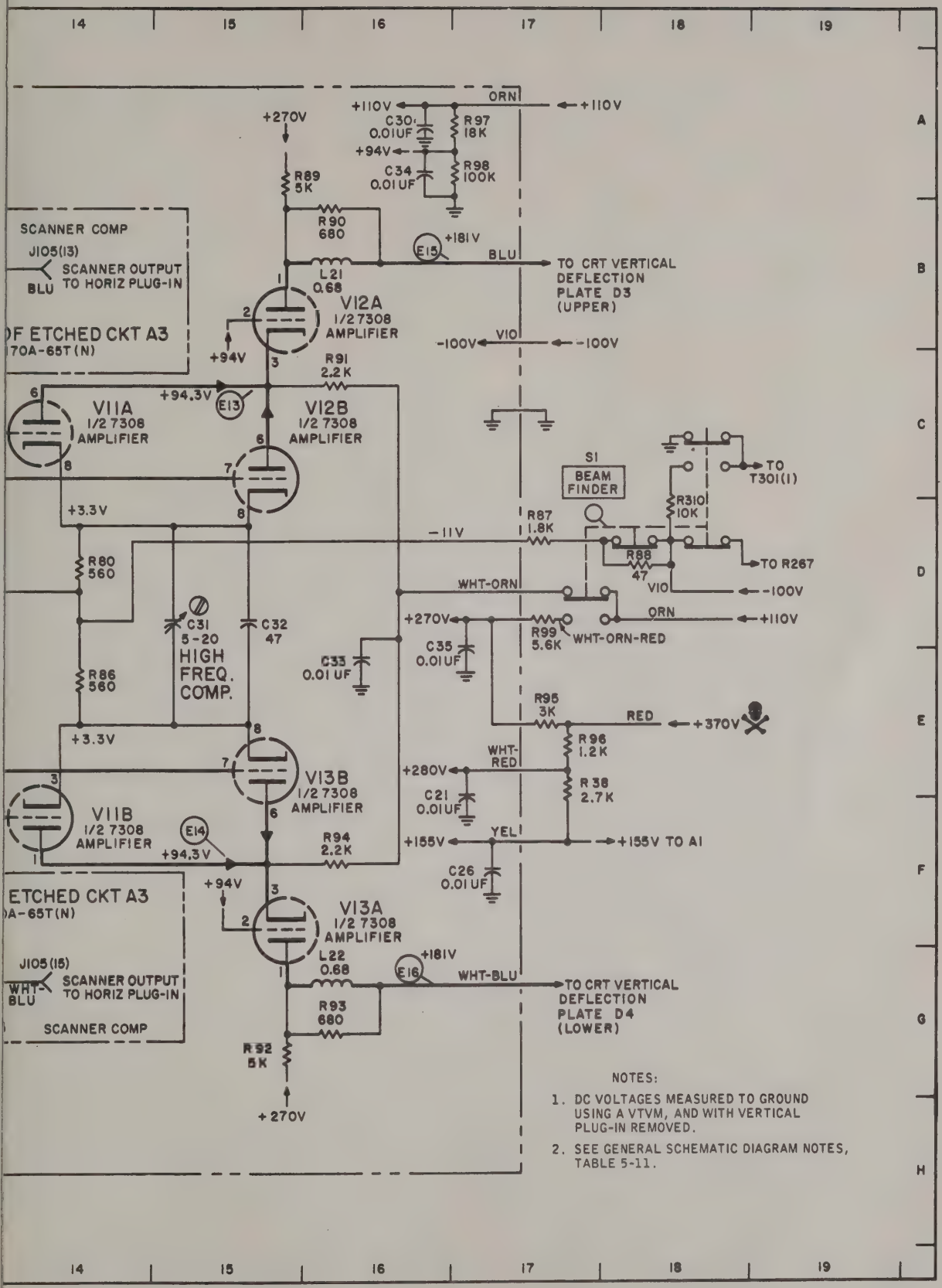


Figure 5-37. Main Vertical Amplifier Schematic Diagram

TABLE 5-11. GENERAL SCHEMATIC DIAGRAM NOTES

1. Component values expressed in ohms, microhenries, and picofarads unless otherwise noted.
2. —— - - —— indicates etched circuit assembly boundaries.
3. Names of panel controls and connectors are enclosed in boxes.
4. Primary signal paths weighted. Feedback paths weighted and dashed.
5. DC voltages are preceded by "+" or "-". AC signal and ripple voltages are followed by VP-P.
6. The letters CW or CCW, placed adjacent to the appropriate terminals of a potentiometer, indicate the direction of rotation viewed from the shaft end.
7. AC signal and ripple voltages are measured with another AN/USM-140B Oscilloscope using the AM-3567/USM High Gain Differential Amplifier. An equivalent oscilloscope may be used. 400 cps sine waves are used for signal voltage measurements except where other waveforms are shown.
8. DC voltages are measured with the AN/USM-116 Voltmeter unless otherwise noted.
9. Special conditions or switch settings required for voltage measurements are noted on the schematics.
10. Because resistance measurements in circuits having many semiconductor elements can be misleading (see paragraph 5-5b)because they vary with the method of measurement, no tables of resistance values are given. Instead, a multiplicity of voltage test points is indicated, and additional voltages are provided in tables on the schematic aprons where necessary.
11. Parts location on each large schematic is given in a table of map-type coordinates on the schematic apron.

REF. DESIG.	SCHEMATIC LOCATION
A1	A7
A2	A15
A3	B14
	F14
C1	E2
C2	F2
C7	F1
C8	G8
C9	H4
C10	F4
C11	H5
C12	F5
C13	G6
C14	F3
C15	C6
C20	G8
C21	F17
C22	B11
C23	E9
C24	D9
C25	F11
C26	F17
C27	D12
C28	G13
C29	B13
C30	A16
C31	D15
C32	D15
C33	E16
C34	A16
C35	E16
DL1	A7
DL2	E7
J105	H7
L1	B4
L2	D4
L3	B6
L4	A6
L5	D6
L6	E6
L9	G4
L10	G5
L13	C8
L14	C8
L15	B8
L16	E8
L17	F8
L18	F8
L19	B10
L20	F10
L21	B16
L22	G16
R1	A2
R2	B2
R3	D2
R4	D2
R5	B3
R6	C3
R7	E2
R8	B4
R9	C4
R11	A6
R12	C5

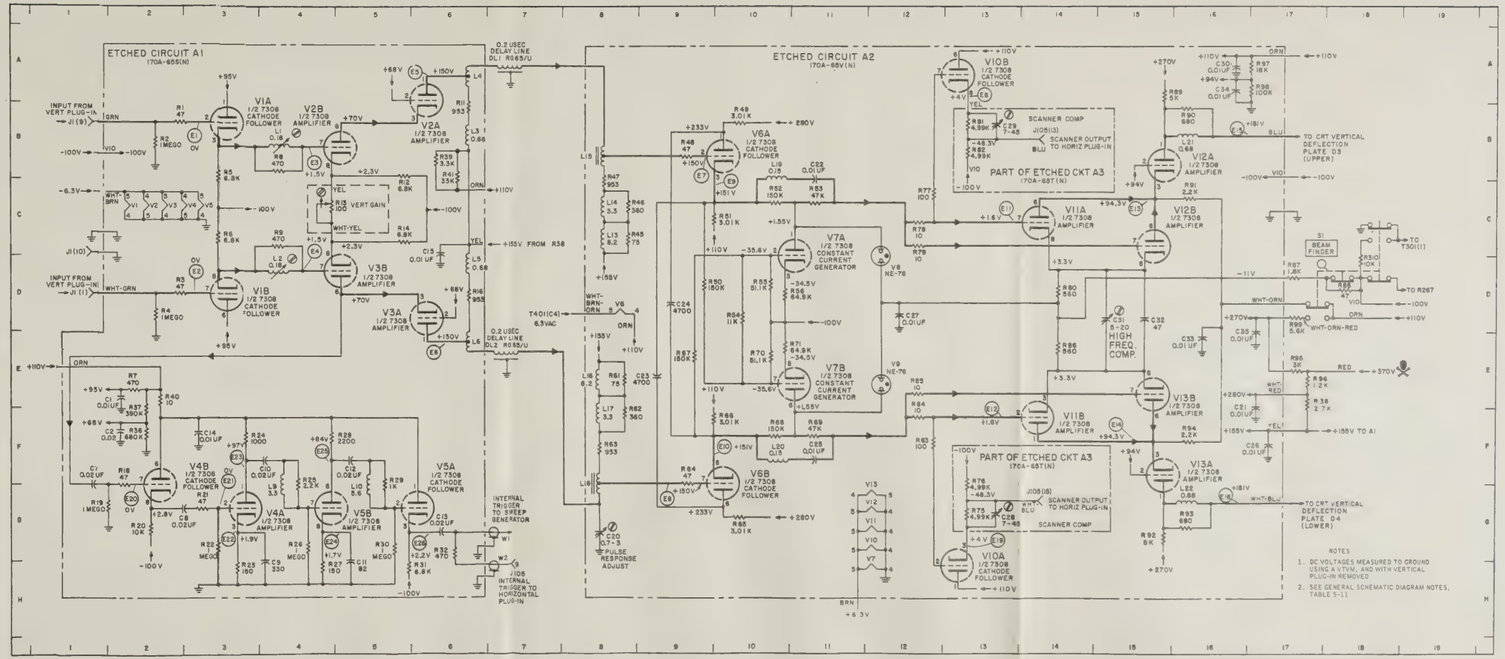
REF. DESIG.	SCHEMATIC LOCATION
R13	C5
R14	C5
R16	D6
R18	F2
R19	G1
R20	G2
R21	G3
R22	G3
R23	H3
R24	F3
R25	F4
R26	G4
R27	H5
R28	F5
R29	F5
R30	G5
R31	H6
R32	G6
R36	F2
R37	E2
R38	E17
R39	B6
R40	E2
R41	B6
R45	C8
R46	C8
R47	B8
R48	B9
R49	B10
R50	D10
R51	C10
R52	C10
R53	C11
R54	D10
R55	D10
R56	D11
R61	E8
R62	F8
R63	F8
R64	F9
R65	G10
R66	F10
R67	E9
R68	F10
R69	F11
R70	E10
R71	E11
R75	G13
R76	F13
R77	B12
R78	C12
R79	C12
R80	D14
R81	B13
R82	B13
R83	F12
R84	E12
R85	E12
R86	E14
R87	D17
R88	D18
R89	A16
R90	B16

REF. DESIG.	SCHEMATIC LOCATION
R91	C16
R92	G15
R93	G16
R94	F16
R95	E17
R96	E17
R97	A17
R98	A17
R99	D17
R310	D18
S1	C17
V1A	A3
V1B	D3
V2A	B6
V2B	B4
V3A	D5
V3B	D5
V4A	G4
V4B	F3
V5A	F6
V5B	G5
V6A	B10
V6B	F10
V7A	C11
V7B	E11
V8	C12
V9	E12
V10A	G13
V10B	A13
V11A	C14
V11B	F14
V12A	B16
V12B	C16
V13A	F16
V13B	E16
W1	G7
W2	G7

Typical DC Voltages in the Vertical Amplifier for the Following Indicated Spot Positions

Test Point	Location	Voltage (Spot 2 cm High) (Spot Center) (Spot 2 cm Low)	Test Point	Location	Voltage (Spot 2 cm High) (Spot Center) (Spot 2 cm Low)
E1	V1(2)	-1.87 -2.07 -2.28	None	V7(6)	+2.4 +1.55 +0.75
E2	V1(7)	-2.28 -2.07 -1.87	E11	V11(7)	+0.75 +1.6 +2.5
E3	V1(3) V2(7)	-0.12 -0.33 -0.55	E12	V11(2)	+2.5 +1.6 +0.75
E4	V1(8) V3(7)	-0.55 -0.33 -0.12	E13	V11(6)	+94.5 +94.3 +94.1
None	V2(6)	+71.6 +71.8 +72	E14	V11(1)	+94.1 +94.3 +94.5
None	V3(6)	+72 +71.8 +71.6	None	V11(8)	+2.5 +3.3 +4.0
E5	V2(1) V6(2)	+149 +150 +151	None	V11(3)	+4.0 +3.3 +2.5
E6	V3(1) V6(7)	+151 +150 +149	E15	V12(1)	+187 +181 +175
E9	V8(3)	+150 +151 +152	E16	V13(1)	+175 +181 +187
E10	V6(8)	+152 +151 +150	E18	V10(8)	+3.1 +4.0 +4.8
None	V7(1)	+0.75 +1.55 +2.4	E19	V10(3)	+4.8 +4.0 +3.1

Conditions of Measurement: Spot set to the three positions using the VERTICAL POSITION control. The voltages shown on the schematic correspond to spot center.



NOTES
1. DC VOLTAGES MEASURED TO GROUND USING A TVM, AND WITH VERTICAL PLUG-IN REMOVED
2. SEE GENERAL SCHEMATIC DIAGRAM NOTES, TABLE 5-1.

Figure 5-37. Main Vertical Amplifier Schematic Diagram

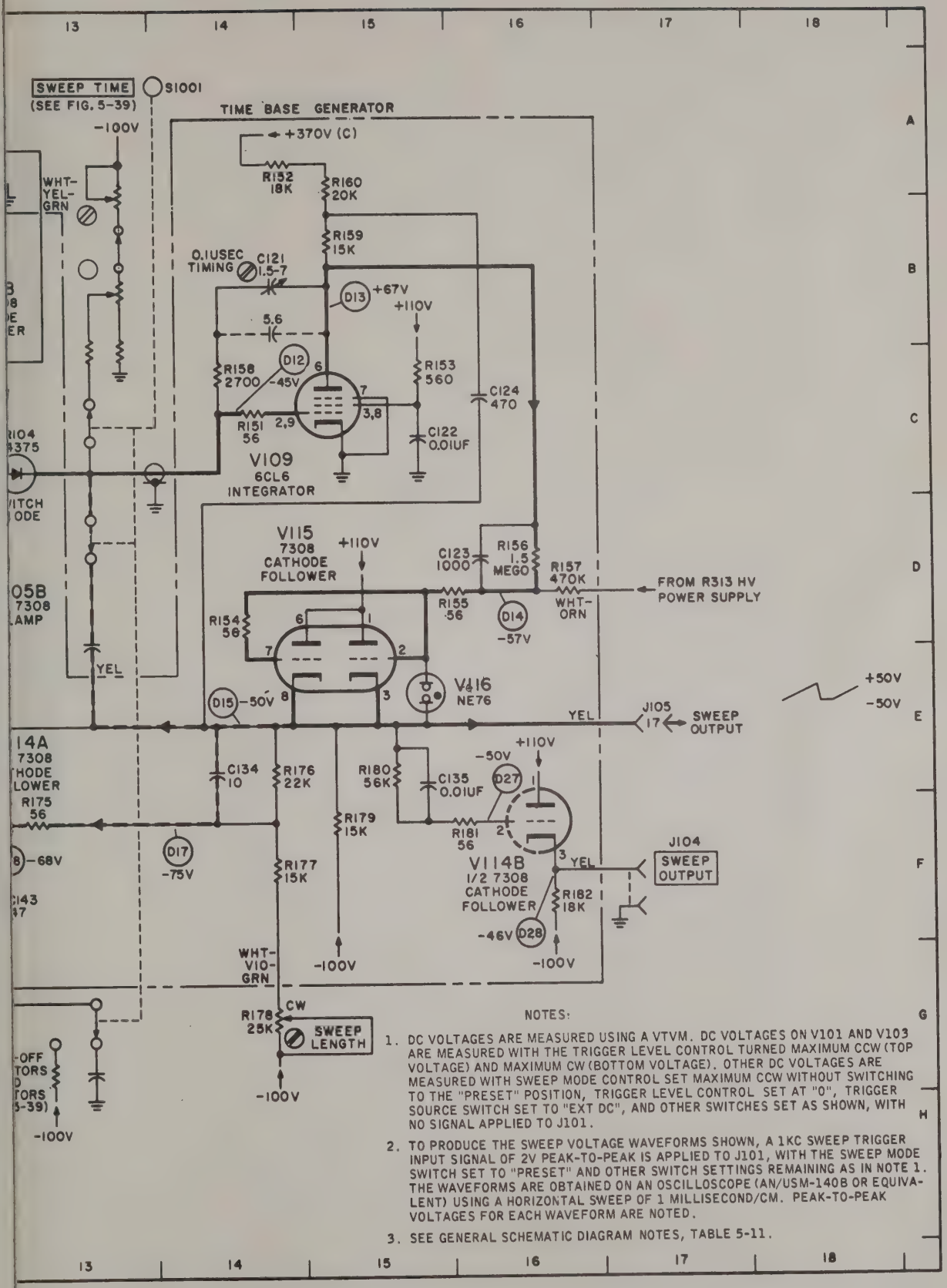


Figure 5-38. Sweep Generator Schematic Diagram

REF. DESIG.	SCHEMATIC LOCATION
A101	A9
CR101	C8
CR102	E8
CR103	C12
CR104	C12
C101	D2
C102	E2
C103	D3
C104	F3
C105	E4
C106	C6
C107	C7
C108	F7
C109	C8
C114	B10
C116	B11
C117	C9
C118	E9
C119	D11
C121	B14
C122	C15
C123	D16
C124	C16
C130	G5
C132	G8
C133	F9
C134	E14
C135	E16
C136	G10
C137	B8
C138	B8
C139	B3
C140	C3
C141	C3
C142	C3
C143	F13
J101	D1
J102	A12
J104	F17
J105	E1
L101	B7
L102	B8
L103	E8
R10	F1
R18	E15
R19	C2
R102	F1
R103	D3
R104	D3
R105	E3
R106	F4
R107	F4
R108	D4
R109	C5
R110	C5
R111	E5
R112	E5
R113	E5
R114	F5
R115	F5
R116	E6
R117	D6
R118	B7

REF. DESIG.	SCHEMATIC LOCATION
R119	C7
R120	E7
R121	E8
R122	D8
R123	C8
R124	D9
R125	E8
R130	B9
R131	B9
R132	B10
R133	F12
R135	B11
R136	B11
R137	J11
R138	C12
R139	C9
R140	C9
R141	C9
R142	E9
R143	E9
R144	D10
R145	E10
R146	C11
R147	C11
R148	C11
R149	E11
R150	D12
R151	C14
R152	A14
R153	C15
R154	D14
R155	D16
R156	D16
R157	D16
R158	C14
R159	B15
R160	A15
R161	G4
R162	G3
R163	H4
R164	H3
R165	F10
R167	F8
R168	E8
R169	E8
R170	F9
R171	G9
R172	G9
R173	F10
R174	G10
R175	F13
R176	E14
R177	F14
R178	G14
R179	F15
R181	F16
R182	F16
R186	B2
R187	B2
R188	C2
R189	C2
S101	E3
S102	E3

REF. DESIG.	SCHEMATIC LOCATION
S103	G5
S202	E11
V101A	C4
V101B	F4
V102	D5
V103A	D7
V103B	D8
V104A	D9
V104B	B10
V105A	D10
V105B	D13
V107A	A10
V107B	*12
V109	A3
V110	E7
V111	D10
V113A	F7
V113B	F9
V114A	E13
V114B	F16
V115	B4
V116	E16

ORIGINAL

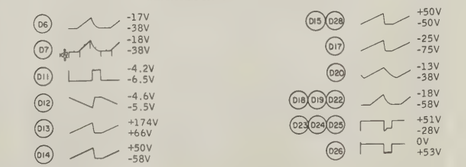
Supplementary Troubleshooting Voltages for
Non-Operating Sweep

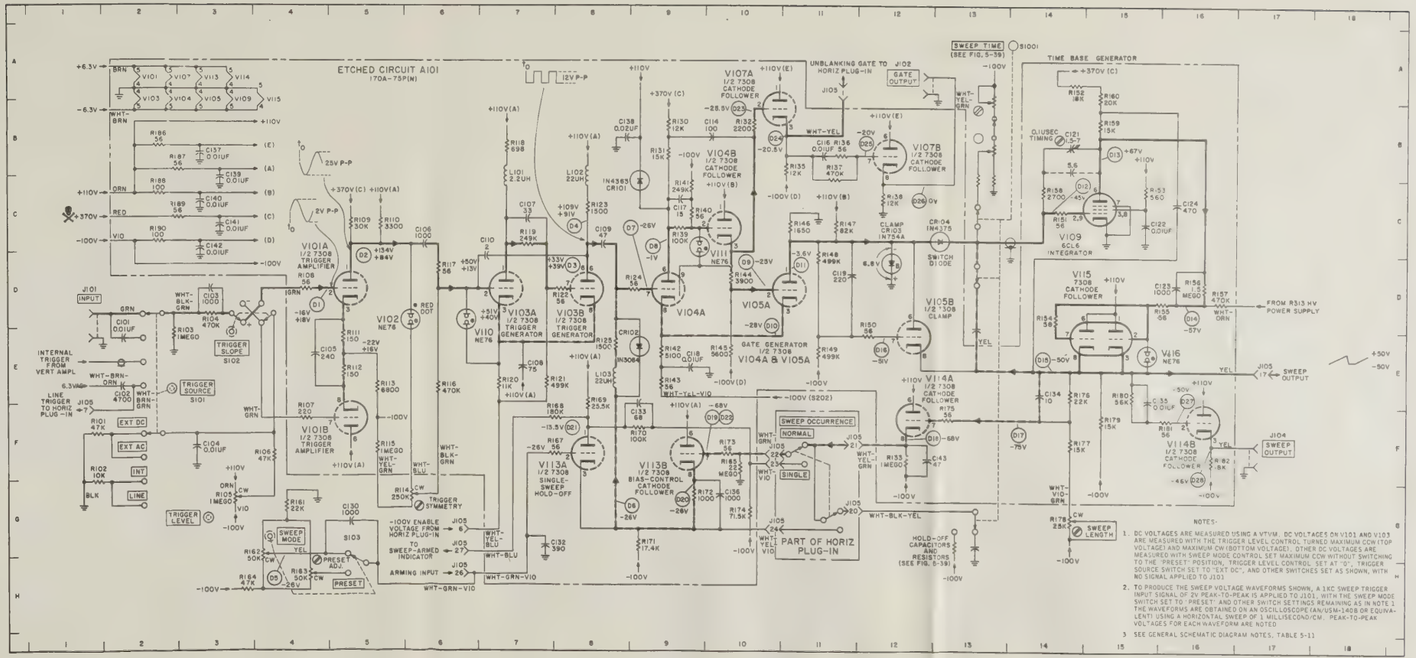
NOTE: Voltages measured by disconnecting R124 from TP D7 and with a clip lead alternately connecting R124 to -100 volts (from any violet lead) and then momentarily to ground; voltage measured for each state with the voltage measured in the grounded condition listed first.

Test Point	Location	Voltage (R124 grounded) (R124 at -100V)
D6	R171	-38. -5.3
D7	V104(7)	-0.36 v -100. v
D8	V104(6)	+8. +110.
None	V104(2)	-22.9 -50.6
D9	V105(2)	-51. -17.
D10	V105(3)	-1.8 -17.
D11	V105(1)	-4.2 -6.5
D12	R151	-4.6 -7.
D13	V109(6)	+66.5 +332.
R157 junction with WHT-ORN lead		+95. +36.
D14	R155	-58. +83.
D15	V115(8)	-51. +85.

Test Point	Location	Voltage (R124 grounded) (R124 at -100V)
D16	V105(7)	-51 -52.
D17	R175	-75. -8.4
D18	V114(8)	-66. -3.
D19	V113(7)	-66. -3.
D20	V113(8)	-38. -0.04
D21	V113(1)	-7. +82.
D22	see D19	
D23	V107(2)	-20. +51.
D24	V107(3)	-16. +52.
D25	V107(7)	-15. +50.
D26	V107(8)	0 +53.
D27	V114(2)	-51. +80.
D28	V114(3)	-46. +81.

Waveforms for Test Points Indicated





NOTES:

1. DC VOLTAGES ARE MEASURED USING A VTVM. DC VOLTAGES ON V101 AND V103 ARE MEASURED WITH THE TRIGGER LEVEL CONTROL TURNED MAXIMUM CCW (TOP VOLTAGE) AND MAXIMUM CW (BOTTOM VOLTAGE). OTHER DC VOLTAGES ARE MEASURED WITH SWEEP MODE CONTROL SET MAXIMUM CCW WITHOUT SWITCHING TO THE "PRESET" POSITION, TRIGGER LEVEL CONTROL SET AT "0", TRIGGER SOURCE SWITCH SET TO "EXT DC", AND OTHER SWITCHES SET AS SHOWN, WITH NO SIGNAL APPLIED TO J101.
2. TO PRODUCE THE SWEEP VOLTAGE WAVEFORMS SHOWN, A 1KC SWEEP TRIGGER INPUT SIGNAL OF 2V PEAK-TO-PEAK IS APPLIED TO J101, WITH THE SWEEP MODE SWITCH SET TO "PRESET" AND OTHER SWITCH SETTINGS REMAINING AS IN NOTE 1. THE WAVEFORMS ARE OBTAINED ON AN OSCILLOSCOPE (AN/USM-140B OR EQUIVALENT) USING A HORIZONTAL SWEEP OF 1 MILLISECOND/CM. PEAK-TO-PEAK VOLTAGES FOR EACH WAVEFORM ARE NOTED.
3. SEE GENERAL SCHEMATIC DIAGRAM NOTES, TABLE 5-11

Figure 5-38. Sweep Generator Schematic Diagram

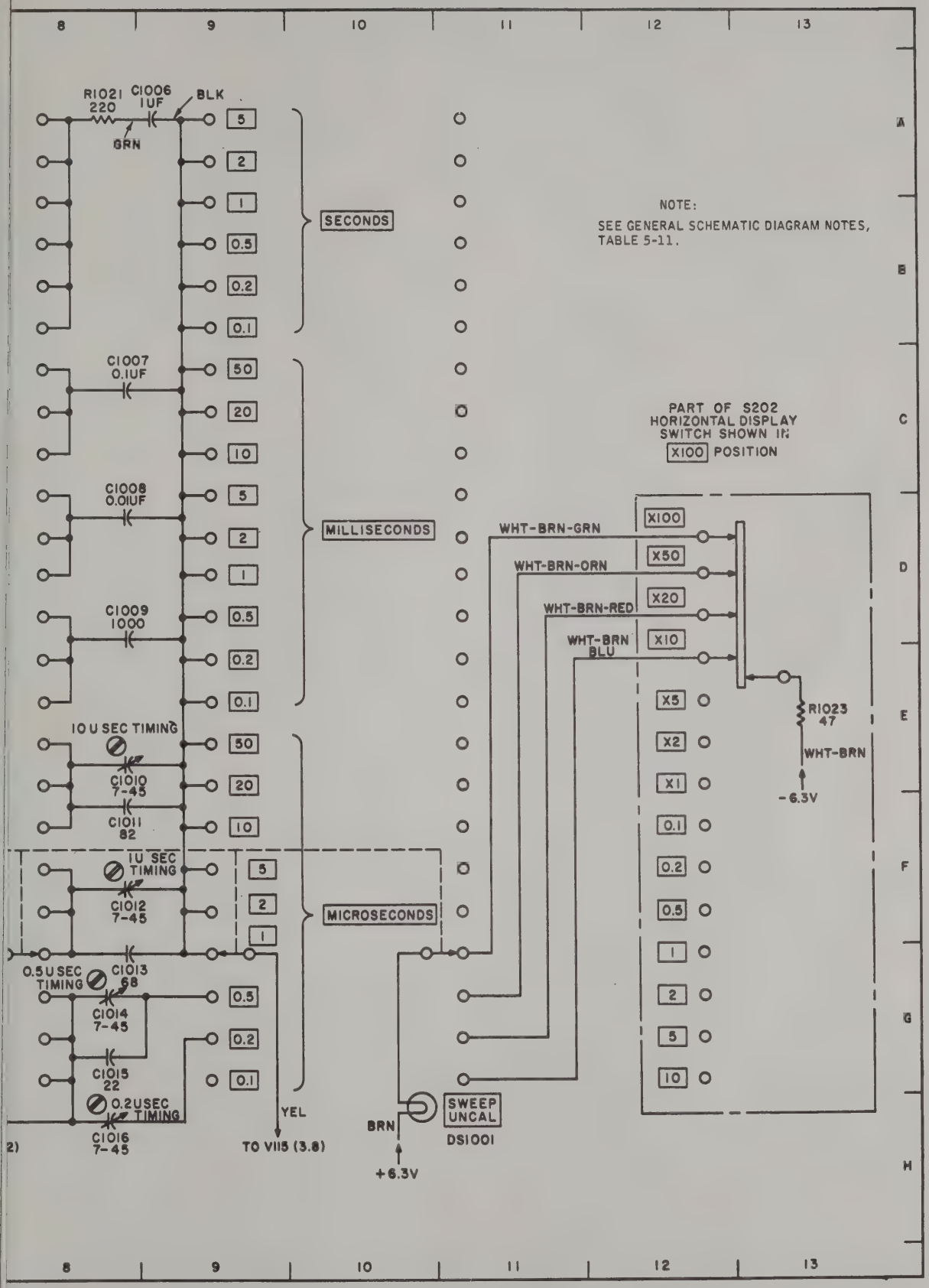


Figure 5-39. Sweep-Time Switch, Functional Schematic Diagram

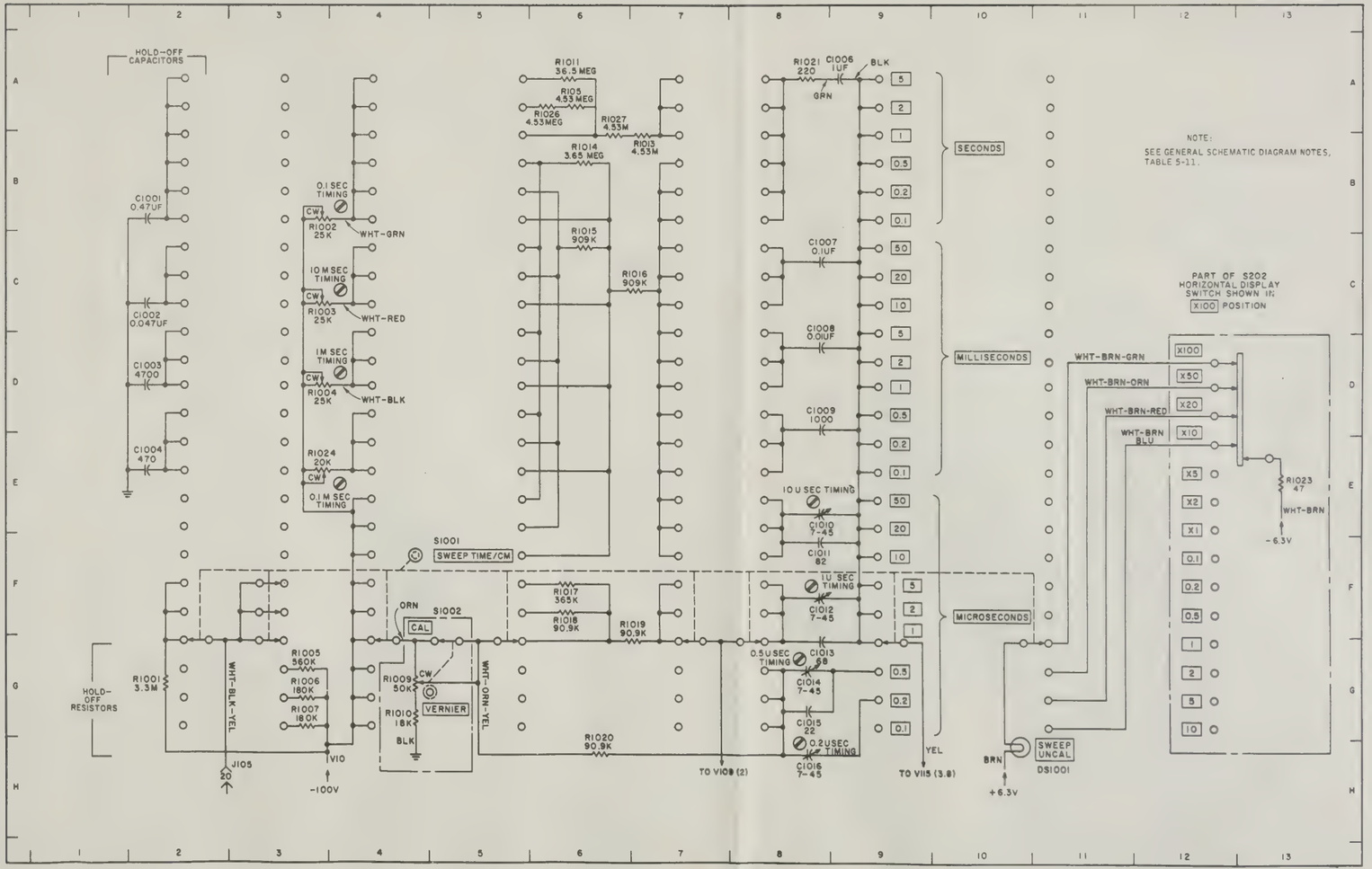


Figure 5-39. Sweep-Time Switch, Functional Schematic Diagram

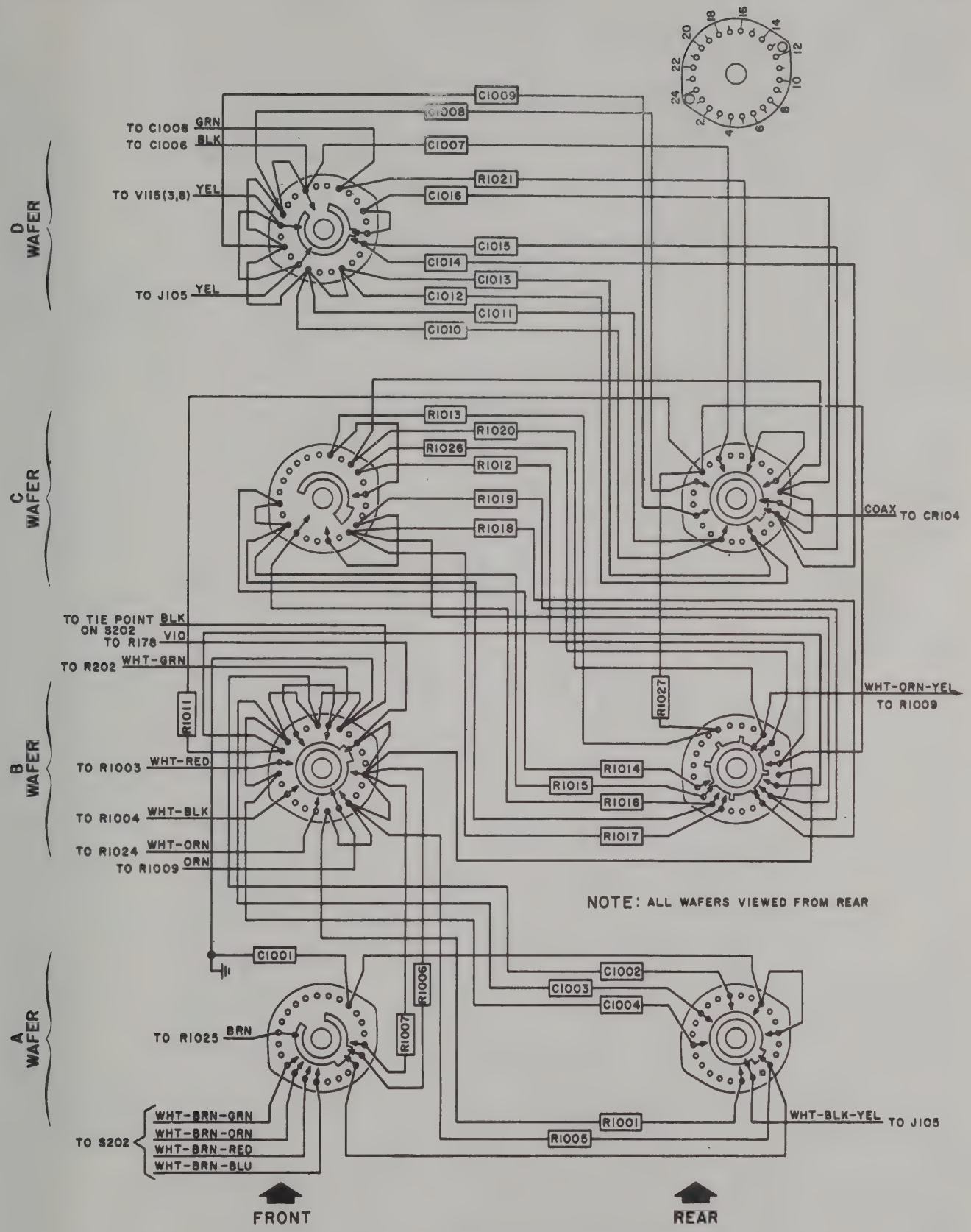


Figure 5-40. Sweep-Time Switch, Wiring Diagram

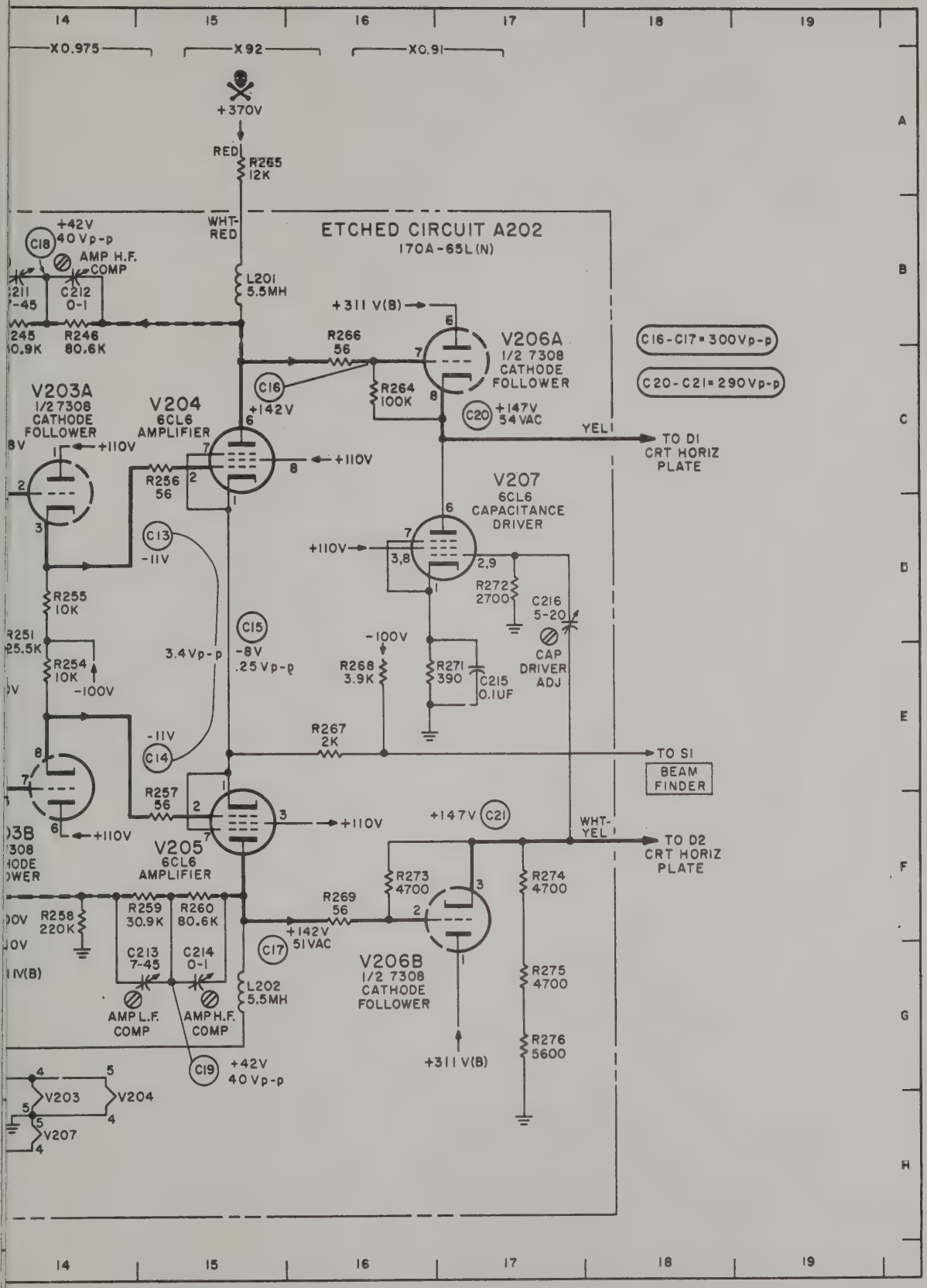


Figure 5-41. Horizontal Amplifier Schematic Diagram

REF. DESIG.	SCHEMATIC LOCATION
A201	A5
A202	B16
A203	A9
C201	B6
C202	C2
C204	B3
C205	B3
C206	C4
C207	C6
C211	B14
C212	B14
C213	G15
C214	G15
C215	E17
C216	D17
C221	G9
J201	C1
L201	B15
L202	G15
Q201	C13
Q202	F13
R201	B6
R202	B6
R203	B3
R204	B3
R205	D4
R206	C4
R207	C5
R208	D5
R209	E6
R210	E6
R211	E6
R212	C6
R213	C6
R214	B6
R215	C8
R216	C8
R217	D9
R218	C9
R221	D9
R222	E9
R223A	D10
R223B	E10
R224	F9
R227	G9
R233	B12
R234	B11
R235	B12
R236	B12
R237	A11

REF. DESIG.	SCHEMATIC LOCATION
R238	A11
R239	D12
R240	E12
R241	E11
R242	E11
R243	A13
R244	B13
R245	B14
R246	B14
R247	D13
R248	D13
R249	C14
R250	D14
R251	D14
R252	E14
R253	F14
R254	E14
R255	D14
R256	C15
R257	F15
R258	F14
R259	F15
R260	F15
R264	C16
R265	A15
R266	E16
R267	E16
R268	E16
R270	G12
R271	E17
R272	D17
R273	F16
R274	F17
R275	G17
R276	G17
R278	G13
S201	D2
S202	A2
S203	A2
V201A	B9
V201B	D5
V202A	D9
V202B	E9
V203A	C14
V203B	F14
V204	C15
V205	F15
V206A	B17
V206B	G16
V207	C17

Typical DC Voltages in the Horizontal Amplifier for the Following Indicated Spot Positions

Test Point	Location	Voltage vs Spot Location 2 cm Left	Center	2 cm Right
C4	V201(7)	-3.3	-3.1	-2.9
C5	V202(2)	0.058	-0.16	0.37
C6	V202(3)	+2.1	+2.2	+2.3
C7	V202(8)	+2.3	+2.2	+2.1
C8	Q201(E)	+2.1	+2.2	+2.3
C9	Q202(E)	+2.3	+2.2	+2.1
C10	Q201(B), Q202(B)	+1.9	+2.0	+2.1
C11	Q201(C)	+14.8	+13.8	+12.8
C12	Q202(C)	+12.8	+13.8	+14.8
C13	V204(2,9)	-12	-11	-10
C14	V205(2,9)	-10	-11	-12
C15	V204(1), V205(1)	-8.0	-8.0	-8.0
C16	V206(7)	+217.5	+142	+73
C17	V206(2)	+73	+142	+217.5
C18	R245-R246	+63	+42.	+21
C19	R259-R260	+21	+42.	+63
C20	V206(8)	+225	+147	+75
C21	V206(3)	+75	+147	+225
None	"+370 (B)"	+322	+311	+294

Conditions of Measurement:

Spot set to the three positions using the HORIZONTAL POSITION control; HORIZONTAL DISPLAY switch set to .1 MV/CM; application of the voltmeter test probe shall not deflect the spot. The voltages shown on schematic correspond to spot center.

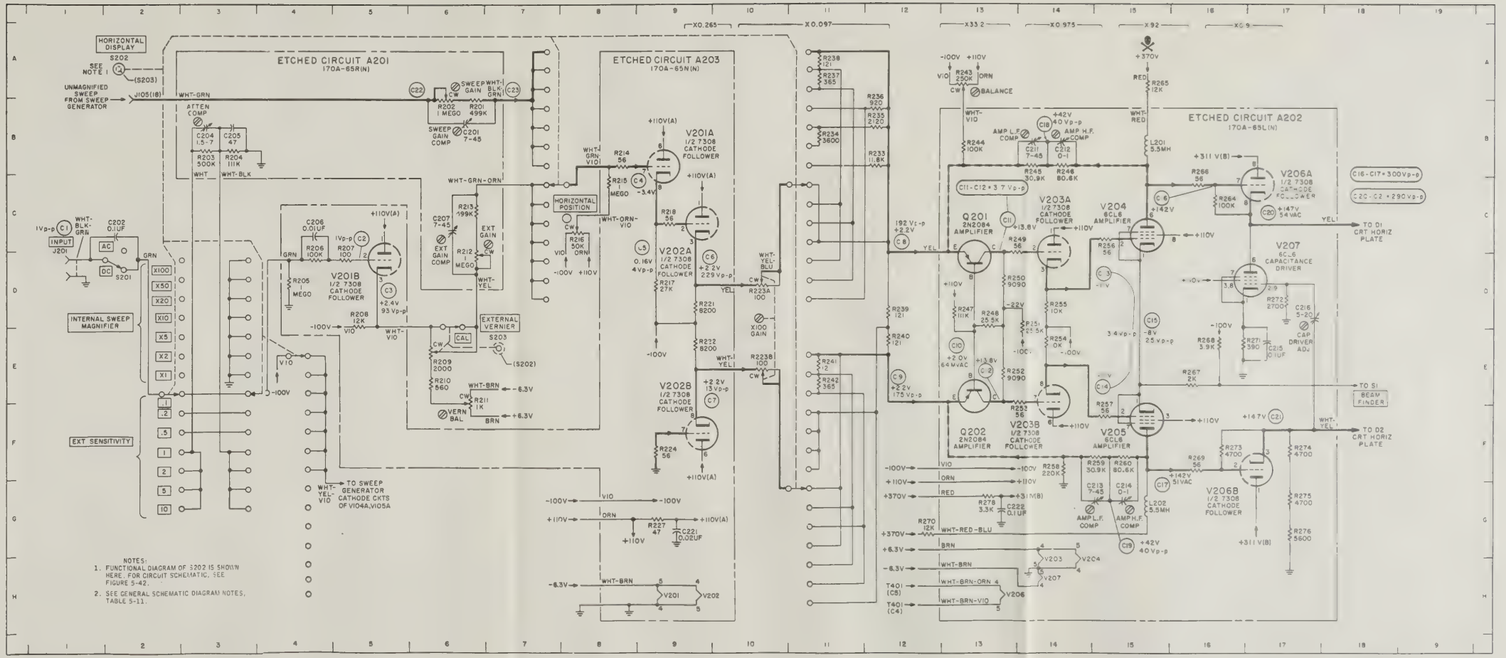


Figure 5-41. Horizontal Amplifier Schematic Diagram

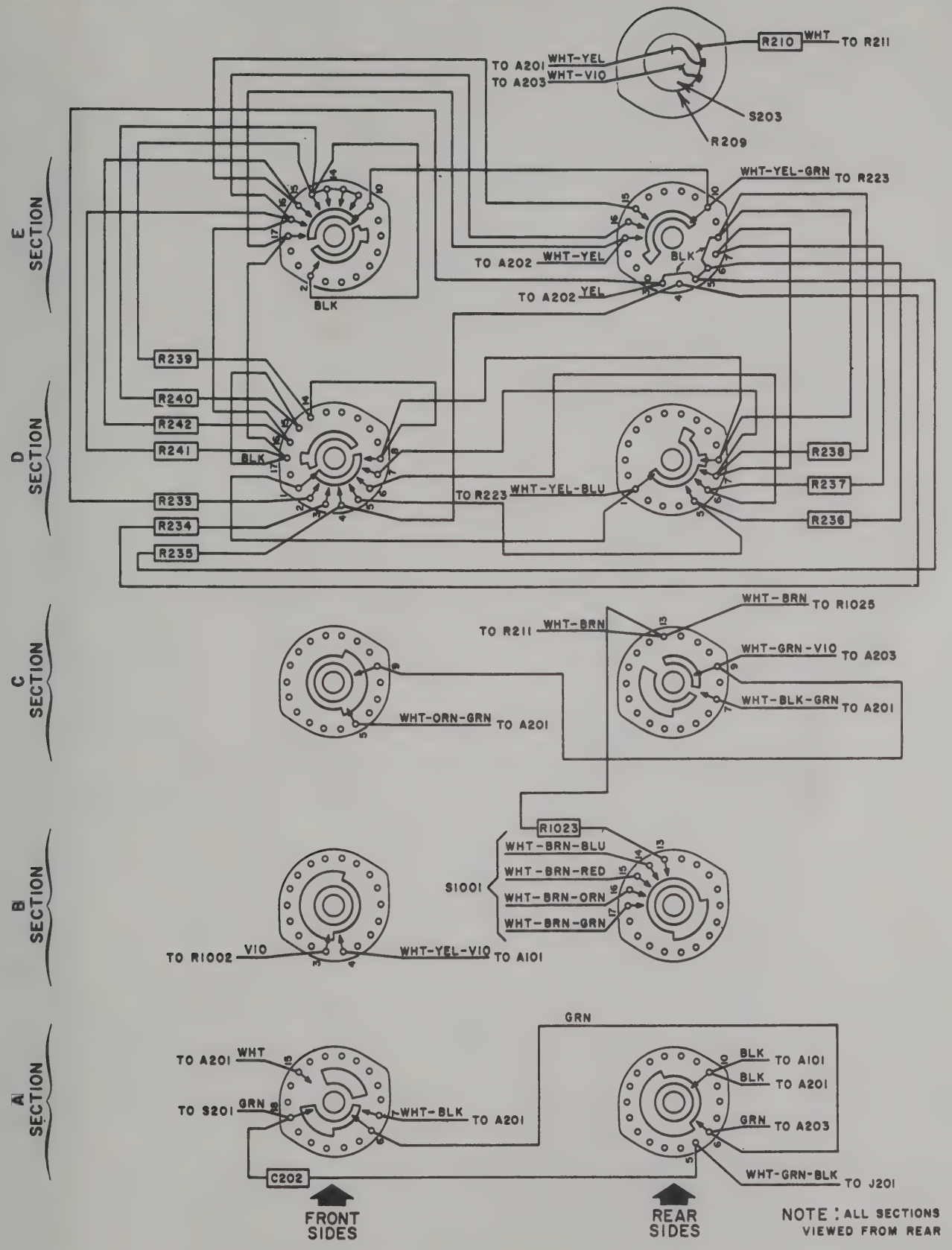


Figure 5-42. Horizontal Display Switch Schematic Diagram

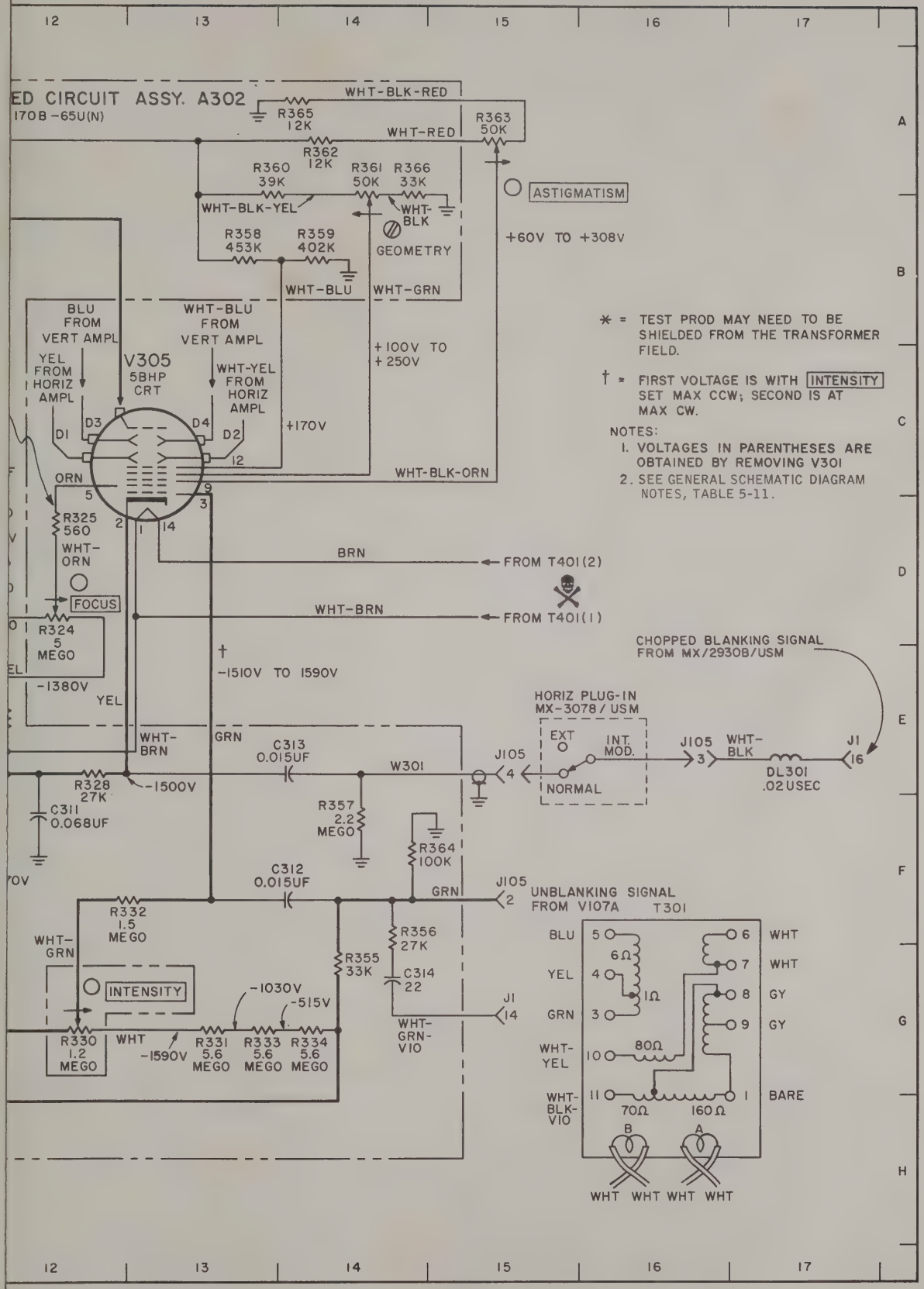


Figure 5-43. High Voltage Power Supply and Calibrator Schematic Diagram

REF. DESIG.	SCHEMATIC LOCATION
C301	B8
C302	A5
C303	D6
C304	D7
C306	C10
C307	F11
C308	G11
C309	D11
C310	F9
C311	F12
C312	F14
C313	E14
C314	G14
C315	C10
C316	C3
C317	C4
C318	G7
DL301	E17
J1	G15
J105	E15
J302	E7
L301	A5
R302	A6
R303	A7
R304	B7
R305	B6
R306	B7
R308	D7
R309	D7
R311	B10
R312	F9
R313	F11
R314	F11
R315	F11
R316	E11
R317	D11
R318	C11
R319	A8
R321	B9
R322	C12
R323	D12
R324	D12
R325	D12
R326	E12
R327	E12
R328	E12
R330	G12
R331	G13
R332	F13
R333	G13
R334	G14

REF. DESIG.	SCHEMATIC LOCATION
R335	C3
R336	D2
R337	D3
R338	D3
R339	D4
R340	D4
R341	H3
R342	B4
R343	E5
R344	E6
R345	F6
R346	F6
R347	F6
R348	G6
R349	G6
R350	G6
R351	H6
R352	H6
R353	E7
R354	F7
R355	G14
R356	F14
R357	F14
R358	B13
R359	B14
R360	A13
R361	A14
R362	A14
R363	A15
R364	F14
R365	A14
R366	A14
R367	F7
R368	C4
S302	E6
T301	F16
T301	C8
V301A	B6
V301B	B7
V303	C7
V304	C6
V305	C13
V306A	C2
V306B	D5
V307A	B5
V307B	C5
V308	C9
V309	D9
V310	E9
V311	G9

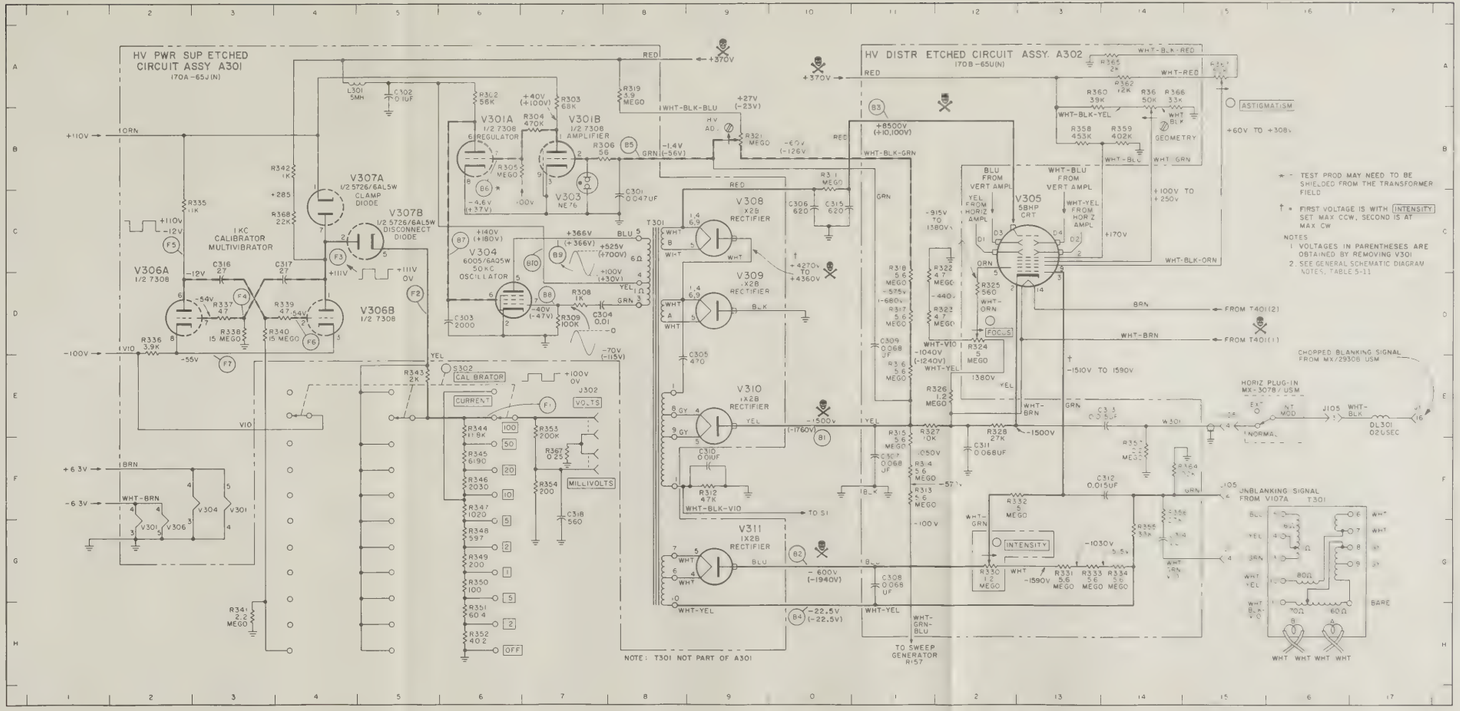


Figure 5-43. High Voltage Power Supply and Calibrator Schematic Diagram

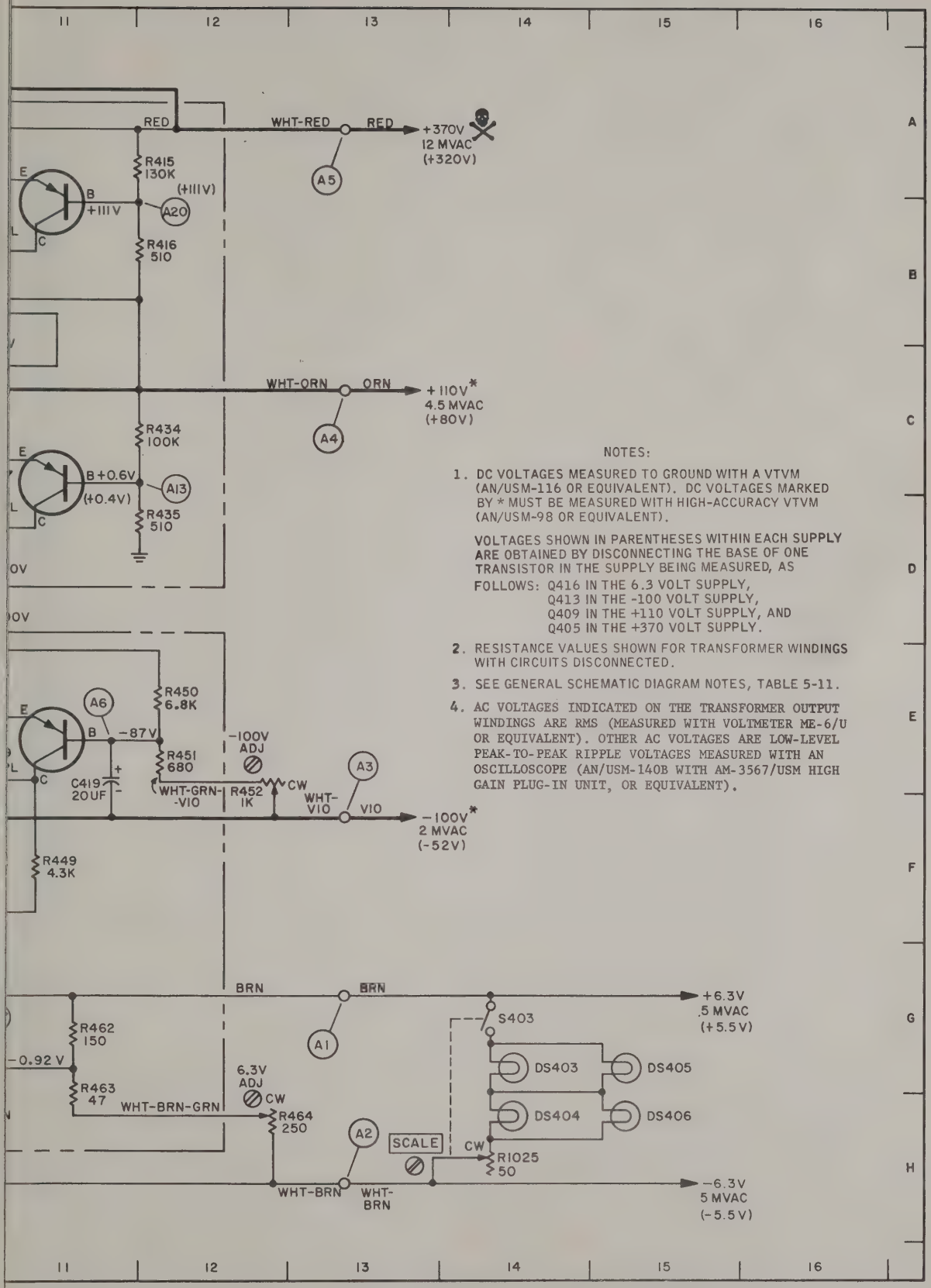


Figure 5-44. Low Voltage Power Supply Schematic Diagram

REF. DESIG.	SCHEMATIC LOCATION
A401	A3
A402	A8
B401	G6
CR401	A3
CR402	A4
CR403	B3
CR404	B3
CR405	C3
CR406	C4
CR407	D3
CR408	D3
CR409	D3
CR410	E4
CR411	E3
CR412	E3
CR413	F10
CR414	G3
CR415	H3
CR416	G9
C401	A4
C402	D9
C403	A5
C404	A3
C405	C3
C406	E3
C407	H3
C408	C4
C409	C9
C410	B9
C411	C5
C412	A8
C413	C8
C416	E4
C417	E8
C418	E9
C419	E11
C420	E5
C425	G4
C426	G9
DS401	E2
DS402	E2
DS403	G14
DS404	H14
DS405	G15
DS406	H15

REF. DESIG.	SCHEMATIC LOCATION
FL401	B2
F401	B1
F402	B2
F403	A5
F404	C5
F405	D5
F406	G5
J401	A2
L402	B4
L403	D5
L404	D4
L405	E5
P401	A2
P402	A1
Q401	A10
Q402	A10
Q403	A5
Q404	A6
Q405	B7
Q406	C10
Q407	C10
Q408	D8
Q409	D7
Q410	E10
Q411	E10
Q412	F8
Q413	F7
Q414	G10
Q415	H8
Q416	H7
Q417	H5
Q418	C6
Q419	E5
R400	E2
R401	D2
R402	A4
R403	B5
R405	B5
R406	B5
R407	C6
R408	A9
R409	B9
R410	B9
R411	B9
R412	A10

REF. DESIG.	SCHEMATIC LOCATION
R413	B10
R415	A12
R416	B12
R417	A8
R421	D5
R422	C5
R423	D5
R424	D6
R425	C9
R426	C8
R427	D8
R428	C9
R430	D9
R431	D9
R432	C10
R433	D10
R434	C12
R435	D12
R438	F5
R439	F5
R440	E5
R441	F5
R442	F6
R443	E8
R444	E8
R445	F9
R446	F8
R447	E9
R448	E10
R449	F11
R450	E12
R451	E12
R452	E12
R458	G5
R459	G8
R460	H5
R461	H9
R462	G11
R463	G11
R464	H13
R1025	H14
S401	C2
S402	H2
S403	G14
T401	A2
V401	E9
W401	A2

Typical Peak-to-Peak Ripple Voltage Levels

TEST POINT	VOLTS
A4-A5	6 mv
A20-A22	10 mv
A22-A25	11 V
A5-A25	11 V
A26	675 V
A4-Gnd	4.5 mv
A13-A16	20 mv
A16-A18	10 V
A4-A18	11 V
A19	475 V
A3-Gnd	2 mv
A6-A9	3 mv
A9-A11	8 V
A12	425 V
A1-A2	2.5 mv
A27-A28	75. mv
A28-A30	1.2 V
A1-A30	1.2 V
A31	130 V

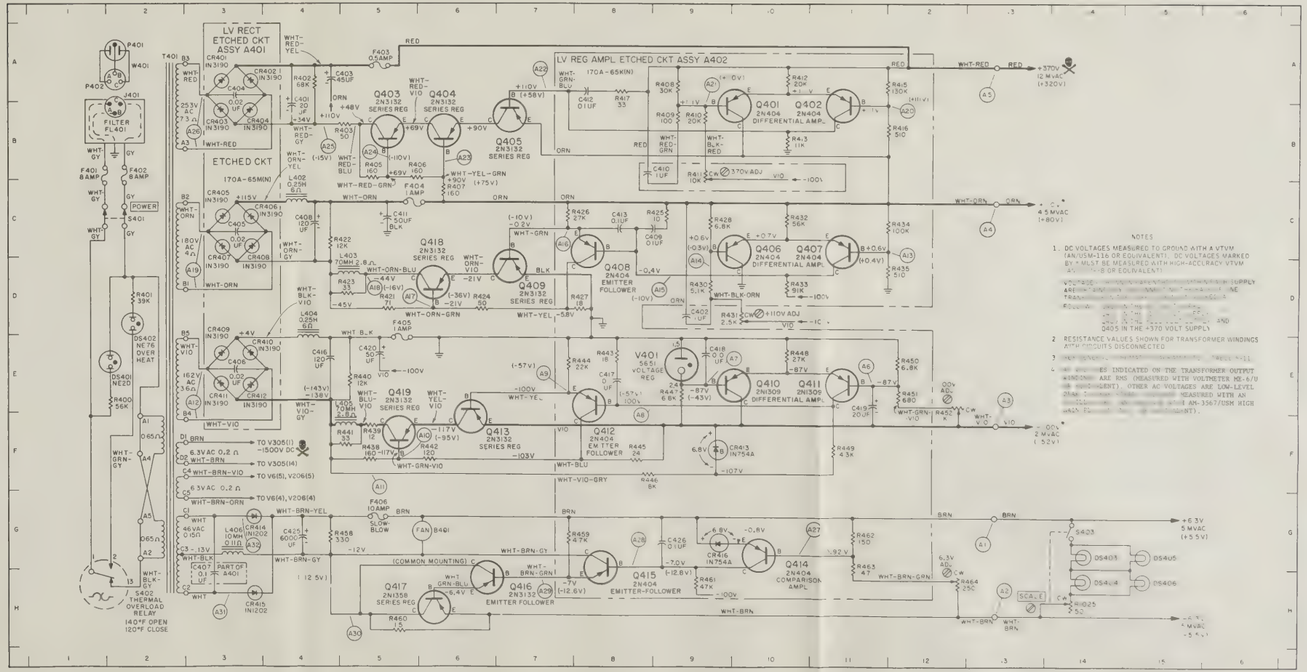

LV RECT ETCHED CKT ASSY A401
LV REG AMPL ETCHED CKT ASSY A402
ETCHED CKT
170A-65M(N)
FILTER FL401
POWER
S401
S402 THERMAL OVERLOAD RELAY 140°F OPEN 120°F CLOSE
DS402 NE76 OVER HEAT
DS401 NE20
Q403 2N3132 SERIES REG
Q404 2N3132 SERIES REG
Q405 2N3132 SERIES REG
Q401 2N2404 DIFFERENTIAL AMPL.
Q402 2N2404 DIFFERENTIAL AMPL.
Q418 2N3132 SERIES REG
Q408 2N2404 EMITTER FOLLOWER
Q409 2N3132 SERIES REG
Q406 2N404 DIFFERENTIAL AMPL.
Q407 2N404 DIFFERENTIAL AMPL.
Q419 2N3132 SERIES REG
Q412 2N2404 EMITTER FOLLOWER
Q413 2N3132 SERIES REG
Q410 2N309 DIFFERENTIAL AMPL.
Q411 2N309 DIFFERENTIAL AMPL.
Q417 2N1358 SERIES REG
Q416 2N3132 EMITTER FOLLOWER
Q415 2N404 EMITTER-FOLLOWER
Q414 2N404A COMPARISON AMPL.
V401 5651 VOLTAGE REG
F403 0.5 AMP
F404 1 AMP
F405 1 AMP
F406 10 AMP SLOW BLOW
+370V 12 MVAC (+320V)
+ 4.5 MVAC (+80V)
- 2 MVAC (-52V)
+6.3V 5 MVAC (+5.5V)
- 4.5 MVAC (-5.4V)
NOTES
1. DC VOLTAGES MEASURED TO GROUND WITH A VTVM (AN/USM-116 OR EQUIVALENT). DC VOLTAGES MARKED BY * MUST BE MEASURED WITH HIGH-ACCURACY VTVM (AN/USM-[illegible] OR EQUIVALENT).
2 RESISTANCE VALUES SHOWN FOR TRANSFORMER WINDINGS ARE APPROXIMATE AND MEASURED WITH OHMMETER.
3 [illegible]
4 [illegible]

Figure 5-44. Low Voltage Power Supply Schematic Diagram

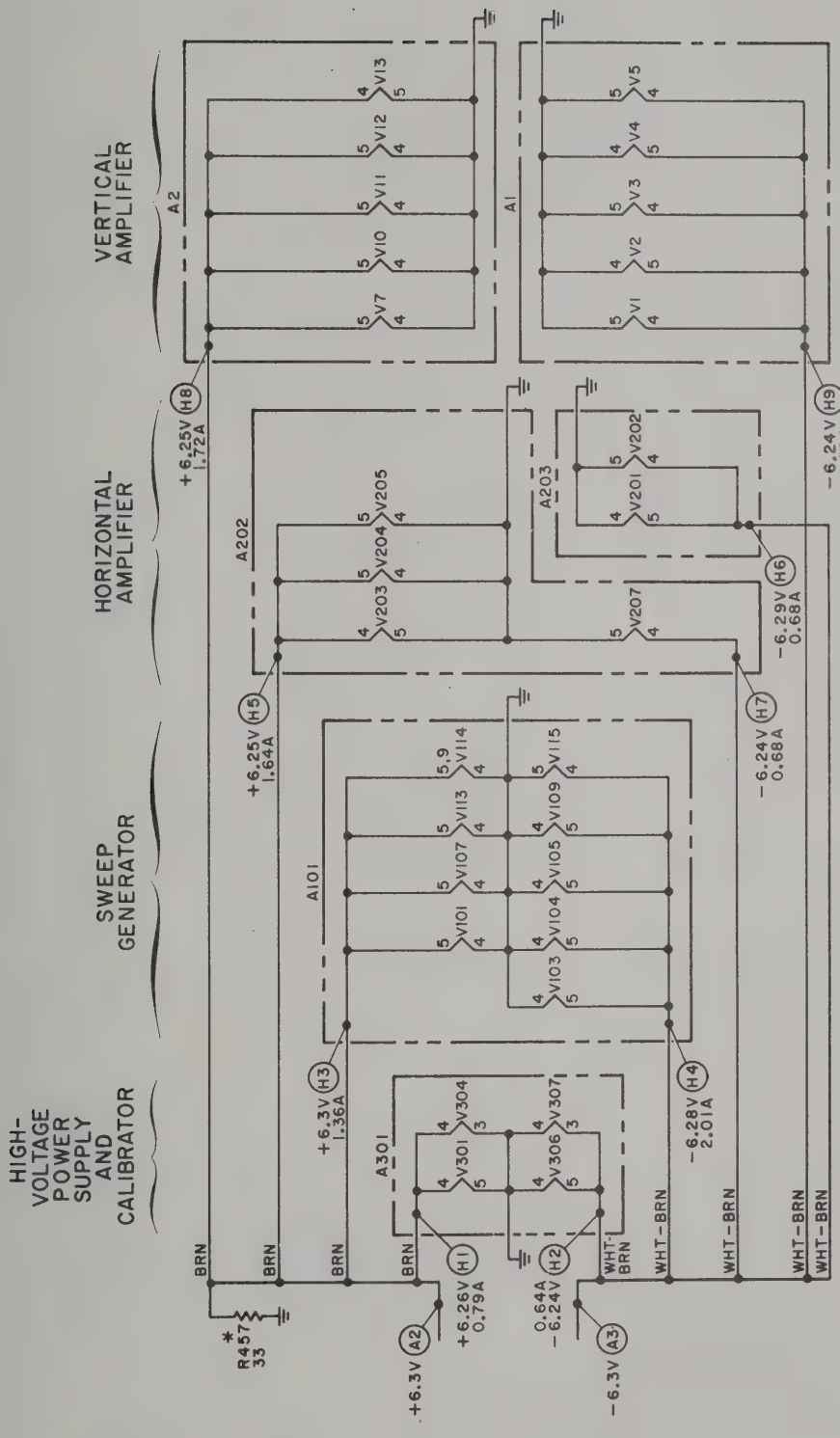


Figure 5-45. Electron Tube Heater Circuit, Functional Diagram

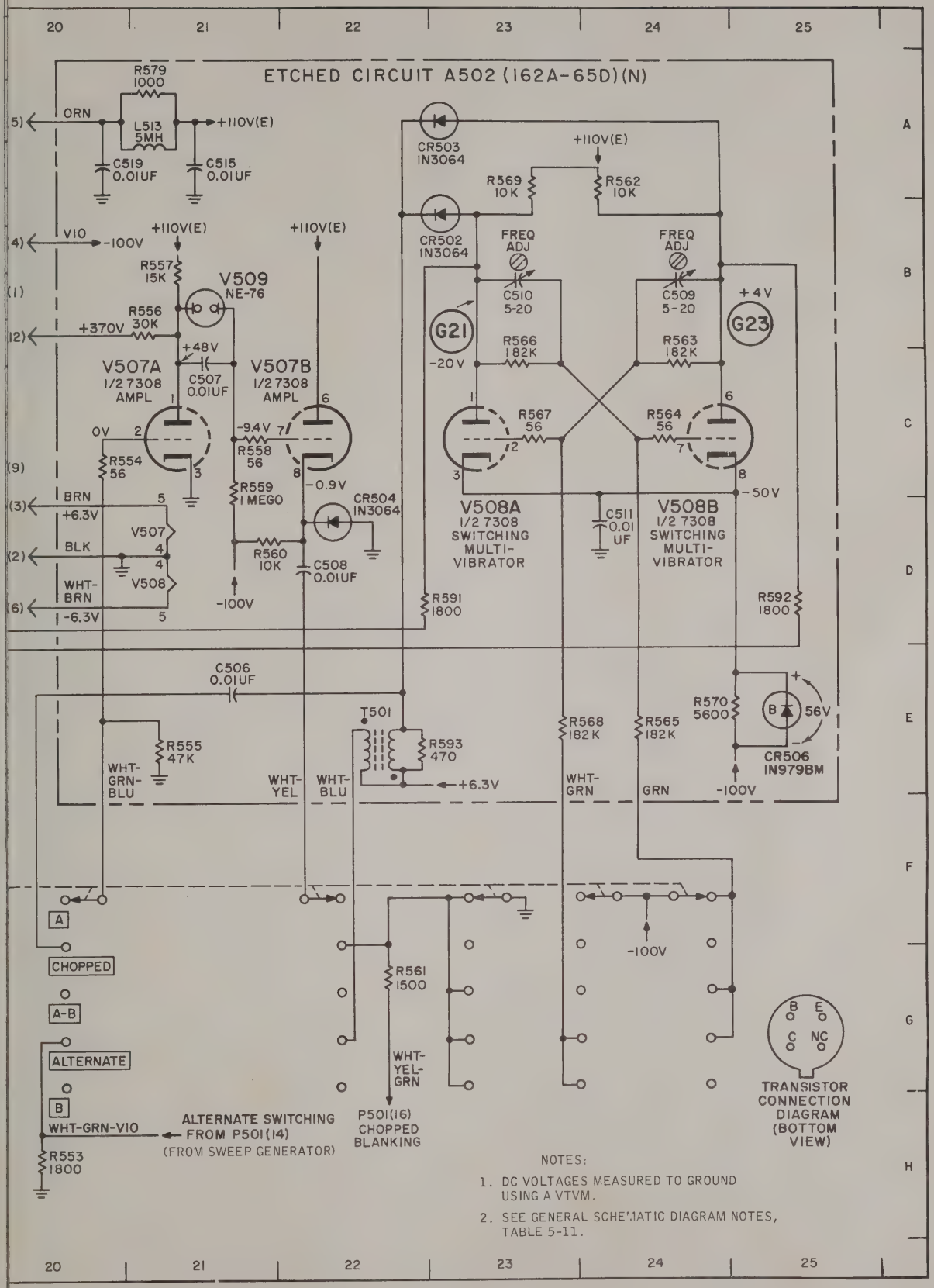


Figure 5-46. MX-2930B/USM Dual Trace Preamplifier Schematic Diagram

REF. DESIG.	SCHEMATIC LOCATION
CR501	D16
CR502	B23
CR503	A23
CR504	D22
CR505	E16
CR506	E25
C503	G11
C504	C18
C506	E21
C507	C21
C508	D22
C509	B24
C510	B23
C511	D24
C515	A21
C516	G11
C517	F11
C518	F11
C519	A20
C522	H18
C523	F18
C1501	A1
C1502	H2
C1503	A4
C1504	B4
C1505	B3
C1506	B4
C1507	B4
C1508	C4
C1509	C3
C1510	C4
C1511	C4
C1512	D4
C1513	D3
C1514	D3
C1515	D4
C1516	D4
C1517	E3
C1518	E3
C1519	E4
C1520	E4
C1521	E3
C1522	E3
C1523	E4
C1524	F3
C1525	F3
C1526	F4
C1527	F4
C1528	F3
C1529	F3
C1530	G4

REF. DESIG.	SCHEMATIC LOCATION
C1531	G4
C1532	G3
C1533	G3
C1534	G4
C1535	G4
C1536	H3
C1537	H3
C1538	H4
C1539	H4
C1540	B3
C1541	C3
C1544	B6
C1545	C6
C1546	A6
C1547	A6
C1548	B5
C1549	B7
C1550	B6
C1551	B6
C1552	C5
C1553	C7
C1554	C6
C1555	C6
C1556	D6
C1557	D6
C1558	D7
C1559	D6
C1560	D5
C1561	D6
C1562	D7
C1563	E6
C1564	E5
C1565	E6
C1566	E7
C1567	F5
C1568	F6
C1569	F6
C1570	F7
C1571	F5
C1572	F6
C1573	F6
C1574	G7
C1575	G5
C1576	G6
C1577	G6
C1578	G7
C1579	H5
C1580	H6
C1581	H6
C1582	H7
C1588	C10

REF. DESIG.	SCHEMATIC LOCATION
C1589	D8
C1590	D8
C1591	A8
C1592	B10
C1593	G8
C1595	E10
J501	A1
J502	H1
L501	B16
L502	C16
L503	B17
L505	D17
L508	E17
L510	H17
L511	F16
L512	G16
L513	A21
L514	B16
L515	C16
L516	B19
L517	C19
L518	F16
L519	G16
P501	A10
P502	B10
Q501	A15
Q502	D15
Q503	E15
Q504	H15
R501	B12
R502	C12
R503	B13
R504	C13
R505	C13
R507	B13
R508	C13
R509	C13
R510A	B14
R510B	C14
R512	A15
R513	D15
R514	C15
R515	C15
R516	B16
R517	D16
R518	B16
R519	B17
R520	C17
R521	C17
R522	D16
R523	B17

REF. DESIG.	SCHEMATIC LOCATION
R524	C17
R525	G11
R527	B12
R528	D12
R529	F17
R530	F17
R531	G17
R532	F16
R533	G16
R534	E16
R535	G16
R536	F15
R537	G15
R538	E15
R540A	F14
R540B	G14
R542	F13
R543	F13
R544	G13
R545	F13
R546	G13
R547	G13
R548	F12
R549	G12
R550	E12
R551	H12
R552	C18
R553	H20
R554	C20
R555	E21
R556	B21
R557	B21
R558	C21
R559	C21
R560	D21
R561	G22
R562	A24
R563	B24
R564	C24
R565	E24
R566	C23
R567	C23
R568	E23
R570	E24
R571	A17
R572	D17
R573	E17
R574	G17
R575	F11
R576	G11

REF. DESIG.	SCHEMATIC LOCATION
R577	A22
R579	A21
R580	F11
R581	F11
R582	B16
R583	C16
R584	A17
R585	D17
R586	B19
R587	D19
R588	F16
R589	G16
R590	E10
R591	D23
R592	D25
R593	E23
R1500	A3
R1501	B4
R1502	B4
R1503	C4
R1504	C4
R1505	D4
R1506	D4
R1507	E4
R1508	E4
R1509	E4
R1510	E4
R1511	F4
R1512	F4
R1513	F4
R1514	F4
R1515	G4
R1516	G4
R1517	G4
R1518	G4
R1519	G4
R1520	H4
R1521	H3
R1522	H4
R1523	H4
R1524	H7
R1530	A6
R1531	B6
R1532	B7
R1533	C6
R1534	C7
R1535	D6
R1536	D7
R1537	D6
R1538	D7
R1539	E6

REF. DESIG.	SCHEMATIC LOCATION
R1540	E7
R1541	E6
R1542	F7
R1543	F7
R1544	F6
R1545	F7
R1546	G7
R1547	G6
R1548	G7
R1549	G7
R1550	G6
R1551	H5
R1552	H7
R1553	H7
R1560	D9
R1561	D10
R1563	A8
R1564	G8
R1568	E10
S501	A1
S502	A5
S503	G2
S504	H5
S505	B8
S506	C14
S507	G14
S508A	B14
S508B	C14
S509A	F14
S509B	G14
T501	E22
V501	B11
V501A	A12
V501B	D12
V502	B11
V502A	A14
V502B	D14
V503A	B18
V503B	D18
V504A	E12
V504B	H12
V505	E14
V505A	E14
V505B	H14
V506	C11
V506A	E18
V506B	G18
V507A	C21
V507B	C22
V508A	D23
V508B	C24
V509	B21

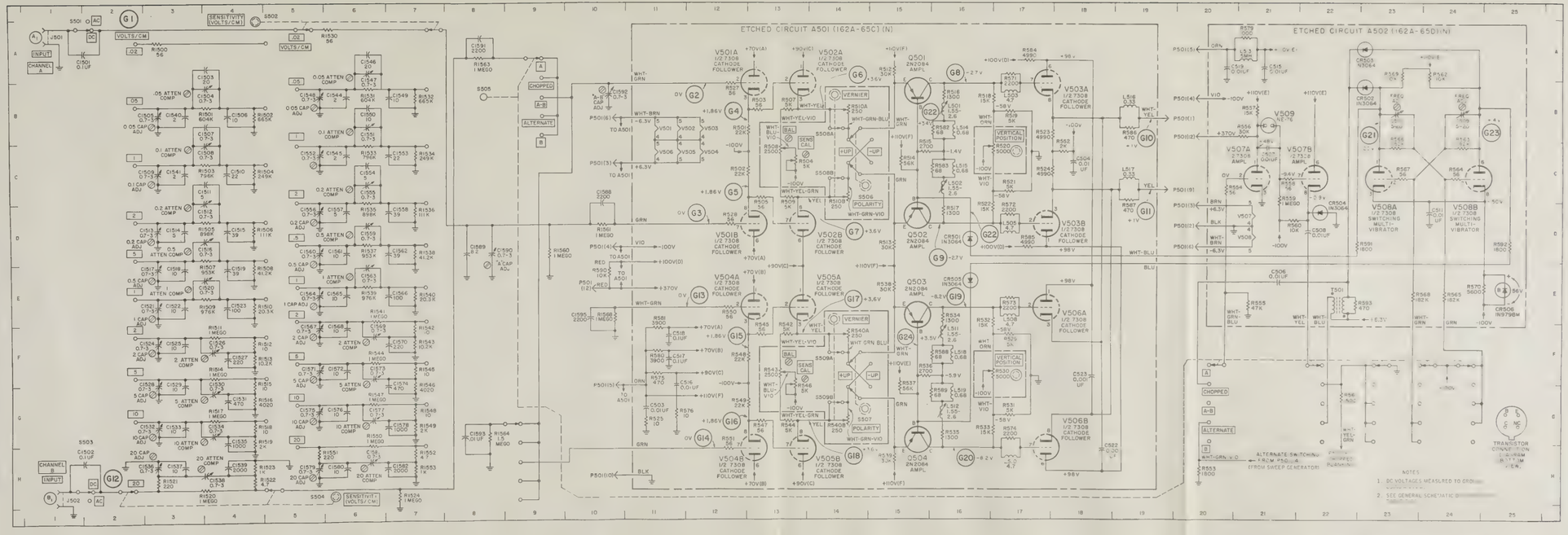

ETCHED CIRCUIT A501 (162A-65C) (N)
ETCHED CIRCUIT A502 (162A-65D) (N)
NOTES
1. DC VOLTAGES MEASURED TO GROUND.
2. SEE GENERAL SCHEMATIC DIAGRAM FOR INTERCONNECTIONS.

Figure 5-46. MX-2930B/USM Dual Trace Preamplifier Schematic Diagram

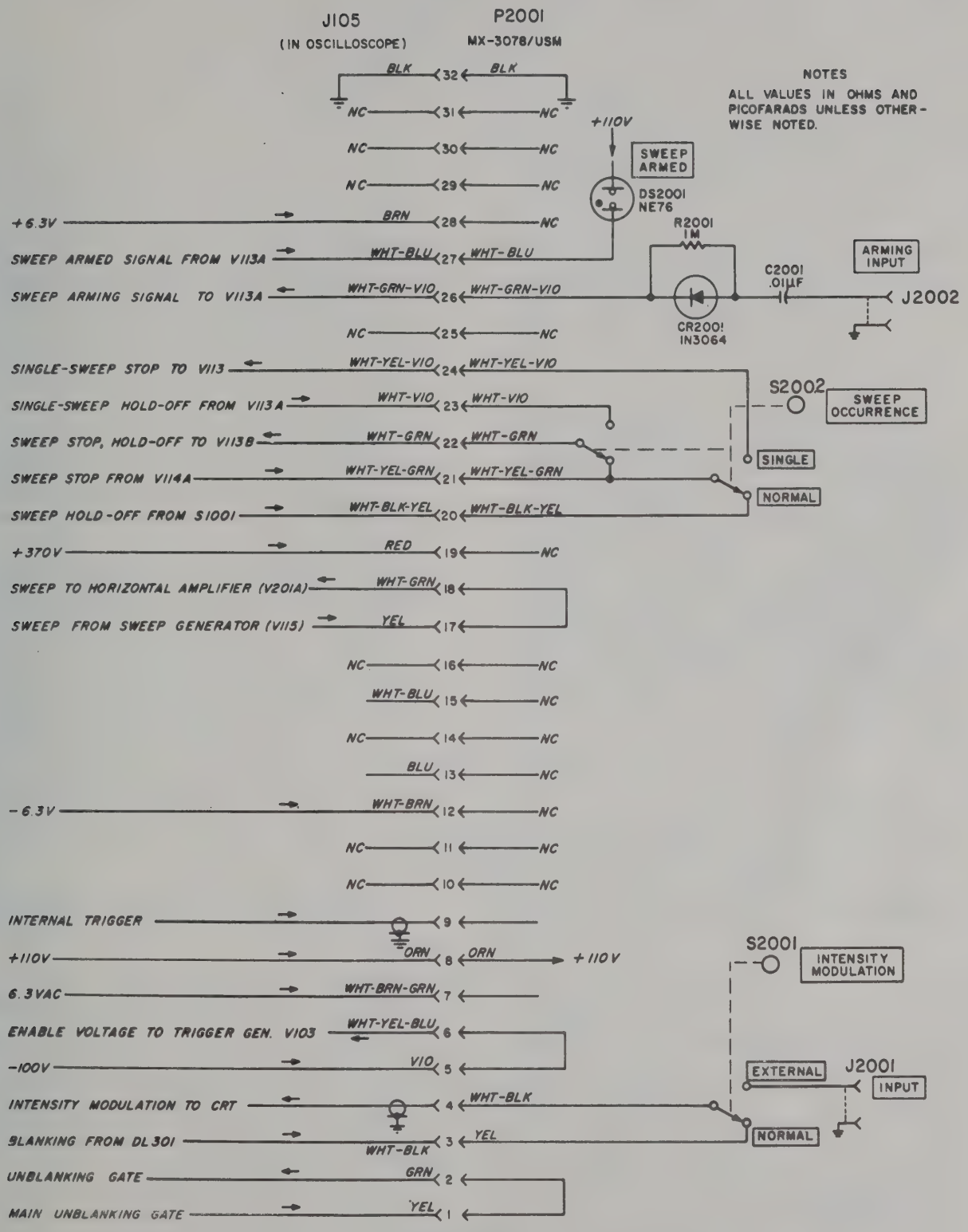


Figure 5-47. MX-3078/USM Horizontal Channel Auxiliary Plug-In Unit Schematic Diagram

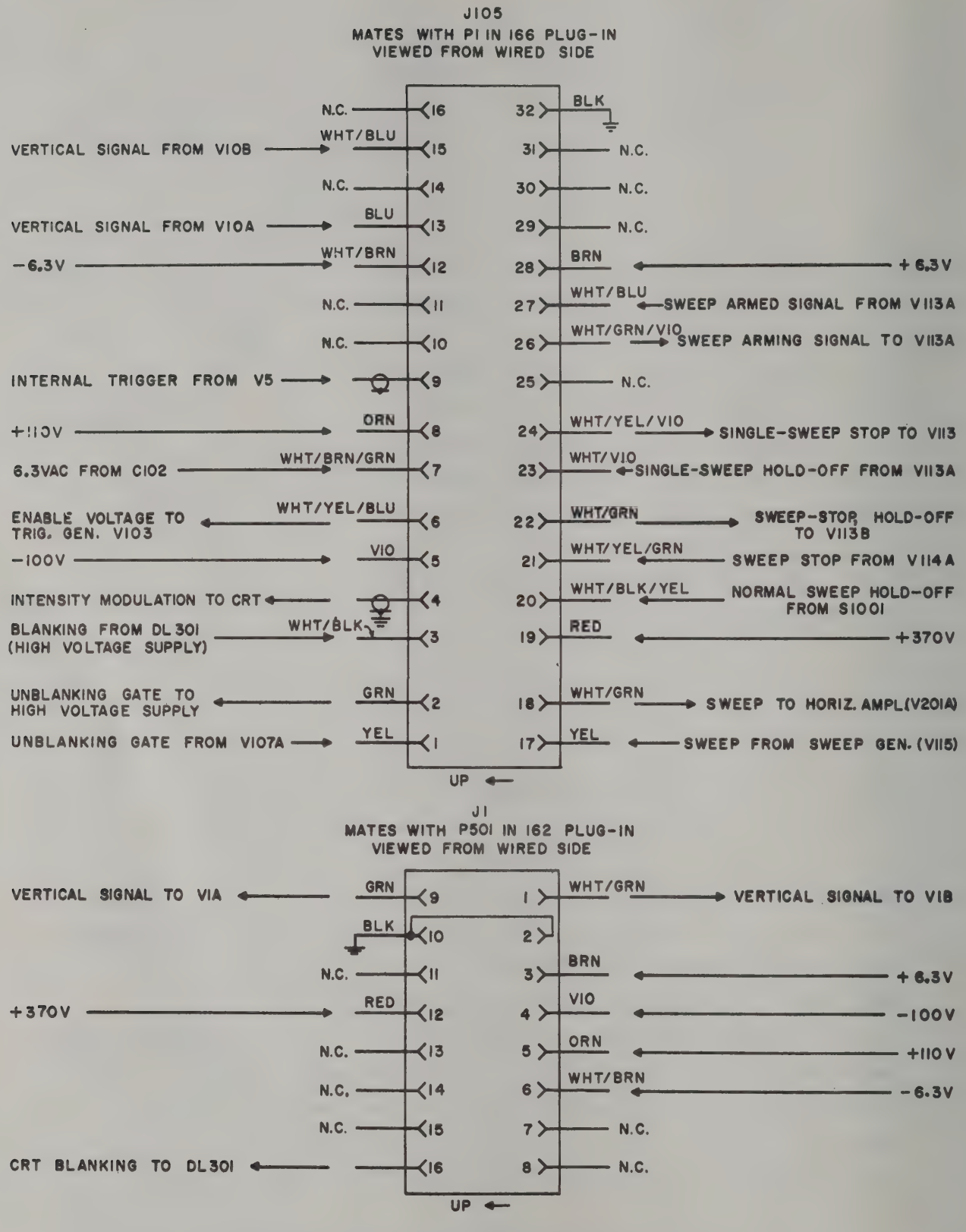


Figure 5-48. Connections to the Horizontal and Vertical Plug-In Connectors J105 and J1

SECTION 6

PARTS LIST

6-1. INTRODUCTION.

a. REFERENCE DESIGNATIONS. — Reference designations are assigned to identify all replaceable parts. They are used for marking the instrument adjacent to the parts they identify, and are also used on the schematics and parts lists. The letter prefix of a reference designation indicates the kind of part, for example, capacitor, resistor, etc. The number differentiates between parts in the same group. Sockets for electron tubes, fuses, and like items include the reference designation of the associated part and a prefix X.

b. BLOCK NUMBERING SYSTEM. — The block numbering method of assigning reference designations has been used to identify parts within the AN/USM-140B, because the construction of the oscilloscope is basically that of a group of circuits packaged as one unit.

Non-repetitive blocks of reference designators have been assigned to the main unit (OS-121B/USM-140) and to the two plug-in units (MX-2930B/USM and MX-3078/USM), so that there is no repetition of reference designators within the entire oscilloscope. Thus, the block numbers serve adequately to identify parts, and no unit number prefixes have been assigned to the reference designators. Examples of this block numbering method are illustrated below:

Example 1:

Block 1 to 99 is assigned to the Main Vertical Amplifier Circuit. Thus, R1 is the first (1) resistor(R) of this subassembly.

Example 2:

Block 100 to 199 is assigned to the Sweep Generator Circuit. Thus, R101 is the first resistor of this subassembly, and R188 also is within this subassembly.

Example 3:

Blocks 500 to 599 and 1500 to 1599 are assigned to the Vertical Channel Dual Trace Preamplifier Plug-In MX-2930B/USM. Thus, R501, R545, and R1545 all are within this unit.

Example 4:

Here's how to locate R401: Turn to table 6-2, the maintenance parts list. Since the block numbering system is used, the list for each unit runs in a continuous sequence from the lowest reference designator number of each letter class (e.g., R1) to the highest reference designator number present (e.g., R1012). The blocks of numbers used in units #2 and #3 are not used in unit #1. Any part can easily be found by scanning to the proper point in the alphabetical-numerical reference designator arrangement of table 6-2. The table also gives a cross-reference to a parts location illustration for each part to enable quick determination of the exact physical location of any part.

6-2. LIST OF UNITS.

Table 6-1 is a listing of the units, comprising the equipment. Table 6-1 also provides the following information for each unit listed: (1) quantity per equipment, (2) official name, (3) designation, (4) colloquial name, and (5) location of the first page of its parts listing in table 6-2.

LIST OF UNITS

UNIT NO.	QTY	NAME OF UNIT	DESIGNATION	COLLOQUIAL NAME	PAGE
1	1	30 MC Dual Trace Oscilloscope	OS-121B/USM-140	Oscilloscope	
2	1	Vertical Channel Dual Trace Preamplifier	MX-2930B/USM	Dual Channel Vertical Plug-In	
3	1	Horizontal Channel Auxiliary Plug-In Unit	MX-3078/USM	Horizontal Plug-In	
4	2	Test Prod	MX-2817/U	Probe	

6-3. MAINTENANCE PARTS LIST.

This section provides replacement parts information for AN/USM-140A Oscilloscope, including the basic plug-in units MX-2930B/USM Vertical Channel Dual Trace Preamplifier and Horizontal Channel Auxiliary Plug-in MX-3078/USM. Table 6-2 lists all units and their maintenance parts. The units are arranged in numerical sequence, and the parts listings are in reference designator alphabetical-numerical order. In addition to listing and describing each part, table 6-2 identifies the illustration which pictorially locates it. The physical location of parts is illustrated in figures 5-9 through 5-36.

The manufacturer and type or part number are given for items which have no military designation.

6-4. LIST OF MANUFACTURERS.

Table 6-3 lists the manufacturers of parts used in the equipment. The table includes the manufacturer's code used in table 6-2 to identify the manufacturers.

TABLE 6-2. MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
A1		MAIN VERTICAL INPUT AMPLIFIER AND INTERNAL TRIGGER SOURCE ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-37; mfr 28480, P/N 170A-65S(N)	5-14
A2		MAIN VERTICAL AMPLIFIER AND DRIVER ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-37; mfr 28480, P/N 170A-65V(N)	5-15
A3		SCANNER OUTPUT ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-37; mfr 28480, P/N 170A-65T(N)	5-16
A4 through A99		Not Used	
A100		SWEEP MODE/TRIGGER SOURCE SWITCH ASSEMBLY: Selector switch and potentiometer assembly with additional components as shown schematically in figure 5-38; mfr 28480, P/N 170A-19E(N)	5-19
A101		SWEEP GENERATOR ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-38; mfr 28480, P/N 170A-65P(N)	5-17
A102		Not Used	
A103		TRIGGER LEVEL/TRIGGER SLOPE SWITCH ASSEMBLY: Rotary switch and potentiometer assembly with additional components as shown schematically in figure 5-38; mfr 28480, P/N 170A-19D(N)	5-20
A104 through A199		Not Used	
A200		EXT VERNIER/HORIZONTAL DISPLAY SWITCH ASSEMBLY: Selector switch and potentiometer assembly with additional components as shown schematically in figure 5-42; mfr 28480, P/N 170A-19A(N)	5-21
A201		HORIZONTAL SENSITIVITY ADJUSTMENT ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-41; mfr 28480, P/N 170A-65R(N)	5-22
A202		MAIN HORIZONTAL AMPLIFIER AND DRIVER ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-41; mfr 28480, P/N 170A-65R(N)	5-23

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
A203		HORIZONTAL IMPEDANCE MATCHING PREAMP ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-41; mfr 28480, P/N 170A-65N(N)	5-24
A204 through A299		Not Used	
A300		CALIBRATOR SWITCH ASSEMBLY: Selector switch with additional components as shown schematically in figure 5-43; mfr 28480, P/N 170A-19C(N)	5-25
A301		HIGH VOLTAGE POWER SUPPLY ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-43; mfr 28480, P/N 170A-65J(N)	5-26
A302		HIGH VOLTAGE DISTRIBUTION ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-43; mfr 28480, P/N 170A-65U(N)	5-27
A303 through A400		Not Used	
A401		LOW VOLTAGE RECTIFIER ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-44; mfr 28480, P/N 170A-65M(N)	5-28
A402		LOW VOLTAGE REGULATOR AMPLIFIER ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-44; mfr 28480, P/N 170A-65K(N)	5-29
A403		POWER CABLE: Three-conductor power input cable terminated in connectors at each end used to connect line power to the instrument; mfr 28480, P/N 170A-16AL(N)	1-1
A404 through A602		Not Used	
A603		CORD CG-409E/U: RF test cable terminated with BNC connectors at each end; mfr 28480, P/N 170A-16AM(N)	1-1
A604		CORD CG-409E/U: RF test cable terminated with BNC connectors at each end; mfr 28480, P/N 170A-16AM(N)	1-1
A605 through A999		Not Used	
A1000		SWEEP TIME SWITCH ASSEMBLY: Selector switch with additional components as shown schematically in figure 5-39; mfr 28480, P/N 170A-19B(N)	5-18

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
B401		MOTOR, ALTERNATING CURRENT: 2400 rpm, 18 vdcw; mfr 62119, part no. YY1W027	5-11 1-1
CP601		CONNECTOR ADAPTER: MIL type UG-255/U	1-1
CP602		CONNECTOR ADAPTER: Same as CP601	1-1
CP603		CONNECTOR ADAPTER: MIL type UG-273A/U	1-1
CP604		CONNECTOR ADAPTER: Same as CP603	1-1
CP605		CONNECTOR ADAPTER: MIL type UG-274B/U	1-1
CP606		CONNECTOR ADAPTER: Same as CP605	1-1
CP607		CONNECTOR ADAPTER: MIL type UG-1035/U	1-1
CP608		CONNECTOR ADAPTER: Same as CP607	1-1
CP609		CONNECTOR ADAPTER: Same as CP607	1-1
CP610		CONNECTOR ADAPTER: Same as CP607	1-1
CR101		SEMICONDUCTOR DEVICE, DIODE: MIL type 1N4363	5-17
CR102		SEMICONDUCTOR DEVICE, DIODE: MIL type 1N3064	5-17
CR103		SEMICONDUCTOR DEVICE, DIODE: JAN type 1N754A	5-17
CR104		SEMICONDUCTOR DEVICE, DIODE: MIL type 1N4375	5-17
CR401		SEMICONDUCTOR DEVICE, DIODE: MIL type 1N3190	5-28
CR402		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR403		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR404		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR405		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR406		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR407		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR408		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR409		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR410		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR411		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR412		SEMICONDUCTOR DEVICE, DIODE: Same as CR401	5-28
CR413		SEMICONDUCTOR DEVICE, DIODE: Same as CR103	5-29
CR414		RECTIFIER: JAN type 1N1202	5-10
CR415		RECTIFIER: Same as CR414	5-10
CR416		SEMICONDUCTOR DEVICE, DIODE: Same as CR403	5-29
C1		CAPACITOR: MIL type CK63AW103M	5-14
C2		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 0.02 μf $\pm$20%, 500 vdcw, hermetically sealed; mfr 72982, part no. 821-011-X5U0203M	5-14
C7		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-14
C8		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-14
C9		CAPACITOR: MIL type CM15D331JN3	5-14
C10		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-14
C11		CAPACITOR: MIL type CM15C820JN3	5-14
C12		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-14
C13		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-14
C14		CAPACITOR: Same as C1	5-14
C15		CAPACITOR: Same as C1	5-14
C20		CAPACITOR, VARIABLE, PLASTIC: 0.7 $\mu\mu$f min, 3.0 $\mu\mu$f max, 350 vdcw, piston type, screwdriver adjustment, ribbon leads; mfr 72982, part no. 535-034 4R	5-15
C21		CAPACITOR: Same as C1	5-15
C22		CAPACITOR: Same as C1	5-15
C23		CAPACITOR: MIL type CK62AW472M	5-15
C24		CAPACITOR: Same as C23	5-15
C25		CAPACITOR: Same as C1	5-15
C26		CAPACITOR: Same as C1	5-15
C27		CAPACITOR: Same as C1	5-15

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
C28		CAPACITOR: MIL type CV11C450	5-16
C29		CAPACITOR: Same as C28	5-16
C30		CAPACITOR: Same as C1	5-15
C31		CAPACITOR: MIL type CV11B200	5-15
C32		CAPACITOR: MIL type CM15C470JN3	5-15
C33		CAPACITOR: Same as C1	5-15
C34		CAPACITOR: Same as C1	5-15
C35		CAPACITOR: Same as C1	5-15
C101		CAPACITOR: Same as C1	5-19
C102		CAPACITOR: Same as C23	5-17
C103		CAPACITOR: MIL type CK62BX102K	5-20
C104		CAPACITOR: Same as C1	5-20
C105		CAPACITOR: MIL type CM15D241JN3	5-17
C106		CAPACITOR: Same as C103	5-17
C107		CAPACITOR: MIL type CM15C330JN3	5-17
C108		CAPACITOR: MIL type CM15C750JN3	5-17
C109		CAPACITOR: Same as C32	5-17
C110		CAPACITOR: MIL type CC20CK020C	5-17
C114		CAPACITOR: MIL type CM15C101JN3	5-17
C116		CAPACITOR: Same as C1	5-17
C117		CAPACITOR: MIL type CC20CH150G	5-17
C118		CAPACITOR: Same as C1	5-17
C119		CAPACITOR: MIL type CM15D221JN3	5-17
C121		CAPACITOR: MIL type CV11A070	5-17
C122		CAPACITOR: Same as C1	5-17
C123		CAPACITOR: Same as C103	5-17
C124		CAPACITOR: MIL type CM15D471JN3	5-17
C130		CAPACITOR: Same as C103	5-19
C132		CAPACITOR: MIL type CM15D391JN3	5-17
C133		CAPACITOR: MIL type CM15C680JN3	5-17
C134		CAPACITOR: MIL type CM15B100KN3	5-17
C135		CAPACITOR: Same as C1	5-17
C136		CAPACITOR: Same as C103	5-17
C137		CAPACITOR: Same as C1	5-17
C138		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-17
C139		CAPACITOR: Same as C1	5-17
C140		CAPACITOR: Same as C1	5-17
C141		CAPACITOR: Same as C1	5-17
C142		CAPACITOR: Same as C1	5-17
C143		CAPACITOR: Same as C32	5-17
C201		CAPACITOR: Same as C28	5-22
C202		CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 μf ±2%, 600 vdcw, 300 vacw, plastic impregnated paper case, epoxy end seal; mfr 01295, part no. 27	5-21
C204		CAPACITOR: Same as C121	5-22
C205		CAPACITOR: Same as C32	5-22
C206		CAPACITOR: Same as C1	5-24
C207		CAPACITOR: Same as C28	5-22
C211		CAPACITOR: Same as C28	5-23
C212		CAPACITOR, FIXED, AIR DIELECTRIC:	5-23
C213		CAPACITOR: Same as C28	5-23
C214		CAPACITOR, FIXED, AIR DIELECTRIC: Same as C212	5-23
C215		CAPACITOR: MIL type CP05A1KE104K3	5-23
C216		CAPACITOR: Same as C31	5-23
C221		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-24
C222		CAPACITOR: MIL type CP09A1KF104K3	5-23

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
C301		CAPACITOR: MIL type CP05A1KC473K3	5-26
C302		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C202	5-26
C303		CAPACITOR: MIL type CK63BX222K	5-26
C304		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 10,000 μμf ±20%, 1000 vdcw, epoxy coated, hermetically sealed; mfr 56289, part no. 29C214A3-H-1038	5-26
C305		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 470 μμf ±20%, 6000 vdcw, durez phenolic wax filled case; mfr 91418, part no. 6KV470	5-26
C306		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 620 μμf +50 -20%, 10,000 vdcw, resin case; mfr 56289, part no. 706C1	5-12
C307		CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.0068 μf ±20%, 3000 vdcw; mfr 96733, part no. W-20836	5-27
C308		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C307	5-27
C309		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C307	5-27
C310		CAPACITOR: Same as C1	5-26
C311		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C307	5-27
C312		CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.015 μf ±10%, 3000 vdcw; mfr 96733, part no. W-20709	5-27
C313		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C312	5-27
C314		CAPACITOR: MIL type CM15C220JN3	5-27
C315		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C306	5-12
C316		CAPACITOR: MIL type CM15C270JN3	5-26
C317		CAPACITOR: Same as C316	5-26
C318		CAPACITOR: MIL type CM20B561KN3	5-25
C401		CAPACITOR, FIXED, ELECTROLYTIC: 120 μf, 450 vdcw, aluminum case, lug type terminals, threaded neck, extended foil swaged; mfr 56289, part no. D29405	5-10
C402		CAPACITOR: MIL type CP05A1KE105K3	5-11
C403		CAPACITOR, FIXED, ELECTROLYTIC: 45 μf, 450 vdcw, aluminum case, lug type terminals, threaded neck, extended foil swaged; mfr 56289, part no. D29401	5-10
C404		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-28
C405		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-28
C406		CAPACITOR, FIXED, CERAMIC DIELECTRIC: Same as C2	5-28
C407		CAPACITOR: Same as C215	5-28
C408		CAPACITOR, FIXED, ELECTROLYTIC: Same as C401	5-11
C409		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C202	5-29
C410		CAPACITOR: Same as C402	5-11
C411		CAPACITOR, FIXED, ELECTROLYTIC: 50 μf, 300 vdcw, aluminum case, lug type terminals, threaded neck, extended foil swaged; mfr 56289, part no. 029402	5-10
C412		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C202	5-29
C413		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 0.1 μf +80 -20%, 50 vdcw, durez coated case; mfr 56289, part no. 33C41	5-29
C416		CAPACITOR, FIXED, ELECTROLYTIC: Same as C401	5-10
C417		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C202	5-29
C418		CAPACITOR: Same as C1	5-29
C419		CAPACITOR: MIL type CL65BK200MP3	5-29
C420		CAPACITOR, FIXED, ELECTROLYTIC: Same as C411	5-10
C425		CAPACITOR, FIXED, ELECTROLYTIC: 6000 μf, 35 vdcw, aluminum case, screw terminals, plastic insulating sleeve; mfr 56289, part no. 32D 315	5-9
C426		CAPACITOR: Same as C215	5-29
C1001		CAPACITOR: MIL type CP09A1KC474K3	5-18
C1002		CAPACITOR: Same as C301	5-18
C1003		CAPACITOR: MIL type CM35D472JN3	5-18

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
C1004		CAPACITOR: Same as C124	5-18
C1006		CAPACITOR: MIL type CQ05B1VC105J	
C1007		CAPACITOR: MIL type CQ05A1VC104J	5-18
C1008		CAPACITOR: MIL type CQ05A1VC103J	5-18
C1009		CAPACITOR: MIL type CM20D102GN3	5-18
C1010		CAPACITOR: Same as C28	5-18
C1011		CAPACITOR: Same as C11	5-18
C1012		CAPACITOR: Same as C28	5-18
C1013		CAPACITOR: Same as C133	5-18
C1014		CAPACITOR: Same as C28	5-18
C1015		CAPACITOR: Same as C314	5-18
C1016		CAPACITOR: Same as C28	5-18
DS401		LAMP: MIL type MS25252-NE2D	5-13
DS402		LAMP, GLOW: Neon, 57 vdc, 0.4 ma, t-2 bulb; mfr 24455, part no. NE76	5-11
DS403		LAMP: MIL type MS15571-2	5-9
DS404		LAMP: Same as DS403	5-9
DS405		LAMP: Same as DS403	5-9
DS406		LAMP: Same as DS403	5-9
DS1001		LAMP: Same as DS403	5-13
FL401		FILTER, LINE: 115 vac, 5 amps, 60/400 cps; or 230 vac, 60 cps; mfr 98734, part no. 0034; includes J401 connector	
F401		FUSE: MIL type F03B250V8A5	5-11
F402		FUSE: Same as F401	5-11
F403		FUSE: MIL type F02A250V1/2AS	5-11
F404		FUSE: MIL type F02A250V1AS	5-10
F405		FUSE: Same as F404	5-10
F406		FUSE: MIL type F03B32V10AS	5-11
J1		CONNECTOR, RECEPTACLE, ELECTRICAL: 16 flat contacts, molded phenolic body; mfr 02660, part no. 26-5200-16S	5-9
J101		CONNECTOR: MIL type MS35179-1094A	5-13
J102		CONNECTOR: Same as J101	5-13
J104		CONNECTOR: Same as J101	5-13
J105		CONNECTOR, RECEPTACLE, ELECTRICAL: 32 flat contacts, molded plastic body; mfr 02660, part no. 26-5200-32S	5-12
J201		CONNECTOR: Same as J101	5-13
J301		CONNECTOR: Same as J101	5-13
J302		CONNECTOR: Same as J101	5-13
J401		CONNECTOR, Part of FL401, not separately replaceable	
L1		INDUCTOR, VARIABLE, RADIO FREQUENCY: 0.18 μh nominal value	5-14
L2		INDUCTOR, VARIABLE, RADIO FREQUENCY: Same as L1	5-14
L3		INDUCTOR: MIL type MS75008-5	5-14
L4		INDUCTOR, RADIO FREQUENCY: 5 μh $\pm$1070; mfr 28480, part no. 170A-60D(N)	5-14
L5		INDUCTOR: Same as L3	5-14
L6		INDUCTOR, RADIO FREQUENCY: Same as L4	5-14
L9		INDUCTOR: MIL type MS15008-10	5-14
L10		INDUCTOR: MIL type MS75008-13	5-14
L13		INDUCTOR: MIL type MS75008-15	5-15
L14		INDUCTOR: Same as L9	5-15
L15		INDUCTOR, RADIO FREQUENCY: 1.7 μh $\pm$10%; mfr 28480, part no. 170A-60E(N)	5-15

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
L16		INDUCTOR: Same as L13	5-15
L17		INDUCTOR: Same as L9	5-15
L18		INDUCTOR, RADIO FREQUENCY: Same as L15	5-15
L19		INDUCTOR: MIL type MS75008-1	5-15
L20		INDUCTOR: Same as L19	5-15
L21		INDUCTOR: Same as L3	5-15
L22		INDUCTOR: Same as L3	5-15
L101		INDUCTOR: MIL type MS75008-8	5-17
L102		INDUCTOR: MIL type MS75008-19	5-17
L103		INDUCTOR: Same as L102	5-17
L201		COIL, RADIO FREQUENCY: 5500 μh ±10%, 200 ma current rating, iron core; encapsulated; mfr 95265, part no. TB-5500-I	5-23
L202		COIL, RADIO FREQUENCY: Same as L201	5-23
L301		INDUCTOR: MIL type MS16223-21	5-26
L402		REACTOR: 250 mh, 0.900 adc; mfr 98734, part no. 1737	5-11
L403		REACTOR: 70 mh, 0.5 adc; mfr 98734, part no. 1476	5-10
L404		REACTOR: Same as L402	5-11
L405		REACTOR: Same as L403	
L406		REACTOR: 0.008 h min., 0.132 ohm max. resistance, 8 adc; mfr 98734, part no. 1522	5-10
MP101	(For A100)	KNOB: 1-5/8 in. dia., 2 setscrews, black phenolic with non-removable brass core; mfr 28480, part no. 0370-0037-9	5-13
MP102	(For A200)	KNOB: Same as MP101	5-13
MP103	(For A103)	KNOB: 3/4 in. dia., fits 3/16 in. dia. shaft, 2 setscrews, red phenolic with removable brass core; mfr 28480, part no. 0370-0061-9	5-13
MP104	(For A100)	KNOB: 3/4 in. dia., fits 1/2 in. dia. shaft, 2 setscrews, red phenolic with non-removable brass core; mfr 28480, part no. 0370-0062-9	5-13
MP105	(For A200)	KNOB: Same as MP104	5-13
MP106	(For A103)	KNOB: 1 in. dia., 2 setscrews, black plastic, molded, with non-removable brass core; mfr 28480, part no. 0370-0067-9	5-13
MP147	(In rear of cabinet)	FILTER, AIR CONDITIONER: Permanent type, aluminum frame 7-15/16 x 7-15/16 x 7/8 inch thick, aluminum mesh corrugated wire cloth; mfr 94330, part no. C-7066-3	2-2
MP201	(For R216)	KNOB: 15/16 in. dia., 2 setscrews, black bakelite with non-removable brass core; mfr 28480, part no. 0370-0029-9	5-13
MP202	(For A1000)	KNOB: Same as MP101	5-13
MP203	(For A1000)	KNOB: Same as MP104	5-13
MP301	(For R324)	KNOB: 3/4 in. dia., 2 setscrews, molded black phenolic with non-removable brass core; mfr 28480, part no. 0370-0026-9	5-13
MP302	(For R330)	KNOB: Same as MP301	5-13
MP303	(For R363)	KNOB: Same as MP301	5-13
MP304	(For A300)	KNOB: 15/16 in. dia., 2 setscrews, black phenolic with non-removable brass core; mfr 28480, part no. 0370-0077-9	5-13
MP306	(For R324 and	SHIELD, RESISTOR: 1-1/2 inches high, 1-5/32 inches wide, 3/4 inches thick, black tenite, molded; mfr 28480, part no. 5040-0418	5-9
MP307	R330)	SHIELD, RESISTOR: Same as MP306	5-9
MP319	(For J101,	INSULATOR, CONNECTOR: 5/8 inch diameter, 0.086 inches thick, thermoplastic; mfr 28480, part no. 5040-0702	5-13
MP320	J102,	INSULATOR, CONNECTOR: Same as MP319	5-13
MP321	J104, and	INSULATOR, CONNECTOR: Same as MP319	5-13
MP322	J201)	INSULATOR, CONNECTOR: Same as MP319	5-13
MP402	(For R1025)	KNOB: Same as MP301	5-13
MP419	(For air fan)	IMPELLER, FAN AXIAL: Counter-clockwise rotation facing air discharge side; aluminum, anodize finish, rubber mounted hub; mfr 28480, part no. 3160-0009-9	5-12

MAINTENANCE PARTS LIST

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REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
MP605	(Part of cover)	LATCH, STEEL: Trunk type; hasp portion; mfr 98003, part no. SC-B-83314-42	1-1
MP606	(Part of cover)	LATCH, STEEL: Same as MP605	1-1
MP607		LATCH, STEEL: Same as MP605	1-1
MP608	(Part of cover)	LATCH, STEEL: Same as MP605	1-1
MP609		GASKET, RUBBER: Neoprene; 5/8 in. wide; 1/16 in. thick material; mfr 02286, part no. 496X	1-1
P401	(Part of power cable)	CONNECTOR: MIL type MS24663	1-1
P402		CONNECTOR: MIL type MS3106R-14S-7S	1-1
P601	(Part of cord CG-409E/U)	CONNECTOR: MIL type UG-88C/U	1-1
P602		CONNECTOR: Same as P601	1-1
Q201		TRANSISTOR: MIL type 2N2084	5-23
Q202		TRANSISTOR: Same as Q201	5-23
Q401		TRANSISTOR: JAN type 2N404	5-29
Q402		TRANSISTOR: Same as Q401	5-29
Q403		TRANSISTOR: MIL type 2N3132	5-10
Q404		TRANSISTOR: Same as Q403	5-10
Q405		TRANSISTOR: Same as Q403	5-10
Q406		TRANSISTOR: Same as Q401	5-29
Q407		TRANSISTOR: Same as Q401	5-29
Q408		TRANSISTOR: Same as Q401	5-29
Q409		TRANSISTOR: Same as Q403	5-10
Q410		TRANSISTOR: JAN type 2N1309	5-29
Q411		TRANSISTOR: Same as Q410	5-29
Q412		TRANSISTOR: Same as Q401	5-29
Q413		TRANSISTOR: Same as Q403	5-10
Q414		TRANSISTOR: Same as Q401	5-29
Q415		TRANSISTOR: Same as Q401	5-29
Q416		TRANSISTOR: Same as Q403	5-10
Q417		TRANSISTOR: JAN type 2N1358	5-10
Q418		TRANSISTOR: Same as Q403	5-10
Q419		TRANSISTOR: Same as Q403	5-10
R1		RESISTOR: MIL type RC20GF470K	5-14
R2		RESISTOR: MIL type RC20GF105K	5-14
R3		RESISTOR: Same as R1	5-14
R4		RESISTOR: Same as R2	5-14
R5		RESISTOR: MIL type RL42AD682J	5-14
R6		RESISTOR: Same as R5	5-14
R7		RESISTOR: MIL type RC32GF471K	5-14
R8		RESISTOR: MIL type RC20GF471K	5-14
R9		RESISTOR: Same as R8	5-14
R11		RESISTOR: MIL type RN60B9530F	5-14
R12		RESISTOR: Same as R5	5-14
R13		RESISTOR: MIL type RV4LAYSA101A	5-9
R14		RESISTOR: Same as R5	5-14
R16		RESISTOR: Same as R11	5-14
R18		RESISTOR: Same as R1	5-14
R19		RESISTOR: Same as R2	5-14
R20		RESISTOR: MIL type RL42AD103J	5-14
R21		RESISTOR: Same as R1	5-14
R22		RESISTOR: Same as R2	5-14
R23		RESISTOR: MIL type RC20GF151K	5-14
R24		RESISTOR: MIL type RC32GF102K	5-14
R25		RESISTOR: MIL type RC20GF222K	5-14

MAINTENANCE PARTS LIST

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REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R26		RESISTOR: Same as R2	5-14
R27		RESISTOR: Same as R23	5-14
R28		RESISTOR: MIL type RC32GF222K	5-14
R29		RESISTOR: MIL type RC20GF102K	5-14
R30		RESISTOR: Same as R2	5-14
R31		RESISTOR: Same as R5	5-14
R32		RESISTOR: Same as R8	5-14
R36		RESISTOR: MIL type RC20GF684K	5-14
R37		RESISTOR: MIL type RL32AD394J	5-14
R38		RESISTOR: MIL type RW29V272	5-9
R39		RESISTOR: MIL type RL42AD332J	5-14
R40		RESISTOR: MIL type RC20GF100K	5-14
R41		RESISTOR: MIL type RC20GF333K	5-14
R45		RESISTOR: MIL type RL20AD750J	5-15
R46		RESISTOR: MIL type RL20AD361J	5-15
R47		RESISTOR: Same as R11	5-15
R48		RESISTOR: MIL type RC07GF470K	5-15
R49		RESISTOR: MIL type RN75B3011F	5-15
R50		RESISTOR: MIL type RN70B1503F	5-15
R51		RESISTOR: Same as R49	5-15
R52		RESISTOR: Same as R50	5-15
R53		RESISTOR: MIL type RC07GF473K	5-15
R54		RESISTOR: MIL type RL20AD113J	5-15
R55		RESISTOR: MIL type RN70B5112F	5-15
R56		RESISTOR: MIL type RN70B6492F	5-15
R61		RESISTOR: Same as R45	5-15
R62		RESISTOR: Same as R46	5-15
R63		RESISTOR: Same as R11	5-15
R64		RESISTOR: Same as R48	5-15
R65		RESISTOR: Same as R49	5-15
R66		RESISTOR: Same as R49	5-15
R67		RESISTOR: Same as R50	5-15
R68		RESISTOR: Same as R50	5-15
R69		RESISTOR: Same as R53	5-15
R70		RESISTOR: Same as R55	5-15
R71		RESISTOR: Same as R56	5-15
R75		RESISTOR: MIL type RN70B4991F	5-16
R76		RESISTOR: Same as R75	5-16
R77		RESISTOR: MIL type RC07GF101K	5-15
R78		RESISTOR: MIL type RC07GF100K	5-15
R79		RESISTOR: Same as R78	5-15
R80		RESISTOR: MIL type RL32AD571J	5-15
R81		RESISTOR: Same as R75	5-16
R82		RESISTOR: Same as R75	5-16
R83		RESISTOR: Same as R77	5-15
R84		RESISTOR: Same as R78	5-15
R85		RESISTOR: Same as R78	5-15
R86		RESISTOR: Same as R80	5-15
R87		RESISTOR: MIL type RW55V182	5-9
R88		RESISTOR: MIL type RC20GF473K	5-9
R89		RESISTOR, FIXED, FILM: 5K ±5%, 3 watts, glass body; mfr 07115, part no. LPI3-502J	5-15
R90		RESISTOR: MIL type RC07GF681K	5-15
R91		RESISTOR: MIL type RL20AD222J	5-15
R92		RESISTOR, FIXED, FILM: Same as R89	5-15
R93		RESISTOR: Same as R90	5-15

MAINTENANCE PARTS LIST

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REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R94		RESISTOR: Same as R91	5-15
R95		RESISTOR: MIL type RW55V302	5-9
R96		RESISTOR: MIL type RW29V122	5-9
R97		RESISTOR: MIL type RL20AD183J	5-15
R98		RESISTOR: MIL type RL20AD104J	5-15
R99		RESISTOR: MIL type RW55G562	
R101		RESISTOR: Same as R88	5-19
R102		RESISTOR: MIL type RC20GF103K	5-19
R103		RESISTOR: Same as R2	5-20
R104		RESISTOR: MIL type RC20GF474K	5-20
R105		RESISTOR, VARIABLE: Part of S102, not separately replaceable.	5-20
R106		RESISTOR: Same as R88	5-20
R107		RESISTOR: MIL type RC20GF221K	5-17
R108		RESISTOR: MIL type RC20GF560K	5-17
R109		RESISTOR, FIXED, FILM: 30K ±10%, 5 watts, deposited metal film, glass body; mfr 07511, part no. LPI5-303K	5-17
R110		RESISTOR: MIL type RL32AD332J	5-17
R111		RESISTOR: Same as R23	5-17
R112		RESISTOR: Same as R23	5-17
R113		RESISTOR: Same as R5	5-17
R114		RESISTOR: MIL type RV4LAYSA254A	5-10
R115		RESISTOR: Same as R2	5-17
R116		RESISTOR: Same as R104	5-17
R117		RESISTOR: Same as R108	5-17
R118		RESISTOR: MIL type RN70B6980F	5-17
R119		RESISTOR: MIL type RN70B2493F	5-17
R120		RESISTOR, FIXED, FILM: 11K ±5%, 4 watts, glass body; mfr 07115, part no. LPI4-113J	5-17
R121		RESISTOR: MIL type RN70B4993F	5-17
R122		RESISTOR: Same as R108	5-17
R123		RESISTOR: MIL type RC20GF152K	5-17
R124		RESISTOR: Same as R108	5-17
R125		RESISTOR: Same as R123	5-17
R130		RESISTOR, FIXED, FILM: 12K ±5%, 5 watts, metallic oxide film, glass body; mfr 07115, part no. LPI5-123J	5-17
R131		RESISTOR, FIXED, FILM: 15K ±5%, 5 watts, metallic oxide film, glass body; mfr 07115, part no. LPI5-153J	5-17
R132		RESISTOR: Same as R25	5-17
R133		RESISTOR: Same as R2	5-17
R135		RESISTOR: MIL type RC42GF123K	5-17
R136		RESISTOR: Same as R108	5-17
R137		RESISTOR: Same as R104	5-17
R138		RESISTOR: Same as R135	5-17
R139		RESISTOR: MIL type RN70B1003F	5-17
R140		RESISTOR: Same as R108	5-17
R141		RESISTOR: Same as R119	5-17
R142		RESISTOR: MIL type RL42AD512J	5-17
R143		RESISTOR: Same as R108	5-17
R144		RESISTOR: MIL type RC42GF392K	5-17
R145		RESISTOR: MIL type RC42GF562K	5-17
R146		RESISTOR: MIL type RN70B1651F	5-17
R147		RESISTOR: MIL type RC20GF823K	5-17
R148		RESISTOR: Same as R121	5-17
R149		RESISTOR: Same as R121	5-17
R150		RESISTOR: Same as R108	5-17

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REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R151		RESISTOR: Same as R108	5-17
R152		RESISTOR: MIL type RL42AD183K	5-17
R153		RESISTOR: MIL type RC20GF561K	5-17
R154		RESISTOR: Same as R108	5-17
R155		RESISTOR: Same as R108	5-17
R156		RESISTOR: MIL type RC20GF155K	5-17
R157		RESISTOR: Same as R104	5-17
R158		RESISTOR: MIL type RC20GF272K	5-17
R159		RESISTOR: MIL type RC32GF153K	5-17
R160		RESISTOR: MIL type RL42AD203K	5-17
R161		RESISTOR: MIL type RC20GF223K	5-19
R162		RESISTOR, VARIABLE: Part of S101, not separately replaceable	5-19
R163		RESISTOR: MIL type RV4LAYSA503A	5-10
R164		RESISTOR: Same as R88	5-19
R165		RESISTOR: MIL type RC20GF226K	5-17
R167		RESISTOR: Same as R108	5-17
R168		RESISTOR: MIL type RC20GF184K	5-17
R169		RESISTOR: MIL type RN75B2552F	5-17
R170		RESISTOR: Same as R139	5-17
R171		RESISTOR: MIL type RN75B1742F	5-17
R172		RESISTOR: Same as R29	5-17
R173		RESISTOR: Same as R108	5-17
R174		RESISTOR: MIL type RN65B7152F	5-17
R175		RESISTOR: Same as R108	5-17
R176		RESISTOR: Same as R161	5-17
R177		RESISTOR: MIL type RC20GF153K	5-17
R178		RESISTOR: MIL type RV4LAYSA253A	5-10
R179		RESISTOR: MIL type RC42GF153K	5-17
R180		RESISTOR: MIL type RC20GF563K	5-17
R181		RESISTOR: Same as R108	5-17
R182		RESISTOR: MIL type RC42GF183K	5-17
R186		RESISTOR: Same as R108	5-17
R187		RESISTOR: Same as R108	5-17
R188		RESISTOR: MIL type RC20GF101K	5-17
R189		RESISTOR: Same as R108	5-17
R190		RESISTOR: Same as R188	5-17
R201		RESISTOR: Same as R121	5-22
R202		RESISTOR: MIL type RV4LAYSA105A	5-22
R203		RESISTOR: MIL type RN65C8983D	5-22
R204		RESISTOR: MIL type RN65C1113D	5-22
R205		RESISTOR: MIL type RN65B1004F	5-24
R206		RESISTOR: MIL type RC20GF104K	5-24
R207		RESISTOR: Same as R188	5-24
R208		RESISTOR: Same as R135	5-24
R209		RESISTOR, VARIABLE: 2 K ±20%, 1 watt, composition, linear taper; mfr 28480, part no. 2100-0220-9	5-21
R210		RESISTOR: MIL type RC32GF561K	5-21
R211		RESISTOR: MIL type RV4LAYSA102A	5-10
R212		RESISTOR: Same as R202	5-22
R213		RESISTOR: Same as R121	5-22
R214		RESISTOR: Same as R108	5-24
R215		RESISTOR: Same as R205	5-24
R216		RESISTOR, VARIABLE: 50 K ±5%, 3 watts, wire-wound, linear taper; mfr 28480, part no. 2100-0121-9	5-13
R217		RESISTOR: MIL type RC42GF273K	5-24

MAINTENANCE PARTS LIST

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REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R218		RESISTOR: Same as R108	5-24
R221		RESISTOR, FIXED, FILM: 8.2K ±5%, 3 watts, glass body; mfr 07115, part no. LPI3-822J	5-24
R222		RESISTOR, FIXED, FILM: Same as R221	5-24
R223A/B		RESISTOR, VARIABLE: 100 ohms ±20%, 1 watt, composition, linear taper, dual sections; mfr 28480, part no. 2100-0216-9	5-10
R224		RESISTOR: Same as R108	5-24
R227		RESISTOR: Same as R1	5-24
R233		RESISTOR: MIL type RN70B1182F	5-21
R234		RESISTOR: MIL type RN70C3611D	5-21
R235		RESISTOR: MIL type RN70B2121F	5-21
R236		RESISTOR: MIL type RN70C9200D	5-21
R237		RESISTOR: MIL type RN70B3650F	5-21
R238		RESISTOR: MIL type RN70B1210F	5-21
R239		RESISTOR: Same as R238	5-21
R240		RESISTOR: Same as R238	5-21
R241		RESISTOR: Same as R238	5-21
R242		RESISTOR: Same as R237	5-21
R243		RESISTOR: Same as R114	5-9
R244		RESISTOR: Same as R206	5-23
R245		RESISTOR: MIL type RN70B3092F	5-23
R246		RESISTOR: MIL type RN75B8062F	5-23
R247		RESISTOR: Same as R204	5-23
R248		RESISTOR: Same as R169	5-23
R249		RESISTOR: Same as R108	5-23
R250		RESISTOR: MIL type RN75B9091F	5-23
R251		RESISTOR: Same as R169	5-23
R252		RESISTOR: Same as R250	5-23
R253		RESISTOR: Same as R108	5-23
R254		RESISTOR: MIL type RC42GF103K	5-23
R255		RESISTOR: Same as R254	5-23
R256		RESISTOR: Same as R108	5-23
R257		RESISTOR: Same as R108	5-23
R258		RESISTOR: MIL type RC20GF224K	5-23
R259		RESISTOR: Same as R245	5-23
R260		RESISTOR: Same as R246	5-23
R264		RESISTOR: Same as R206	5-23
R265		RESISTOR: MIL type RW32G123	5-11
R266		RESISTOR: Same as R108	5-23
R267		RESISTOR, FIXED, FILM: 2K ±5%, 7 watts, deposited metal film, glass body; mfr 07115, part no. LPI7-202J	5-23
R268		RESISTOR: Same as R144	5-23
R269		RESISTOR: Same as R108	5-23
R270		RESISTOR: Same as R265	5-11
R271		RESISTOR: MIL type RC20GF391K	5-23
R272		RESISTOR: Same as R158	5-23
R273		RESISTOR: MIL type RC20GF472K	5-23
R274		RESISTOR: MIL type RC42GF472K	5-23
R275		RESISTOR: Same as R274	5-23
R276		RESISTOR: Same as R145	5-23
R278		RESISTOR: MIL type RC42GF332K	5-23
R302		RESISTOR: MIL type RC42GF563K	5-26
R303		RESISTOR: MIL type RC20GF683K	5-26
R304		RESISTOR: Same as R104	5-26
R305		RESISTOR: Same as R2	5-26
R306		RESISTOR: Same as R108	5-26
R308		RESISTOR: Same as R29	5-26

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REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R309		RESISTOR: Same as R206	5-26
R310		RESISTOR: Same as R102	5-12
R311		RESISTOR: Same as R2	5-12
R312		RESISTOR: Same as R88	5-26
R313		RESISTOR: MIL type RC42GF565K	5-27
R314		RESISTOR: Same as R313	5-27
R315		RESISTOR: Same as R313	5-27
R316		RESISTOR: Same as R313	5-27
R317		RESISTOR: Same as R313	5-27
R318		RESISTOR: Same as R313	5-27
R319		RESISTOR: MIL type RC32GF395J	5-26
R321		RESISTOR: Same as R202	5-9
R322		RESISTOR: MIL type RC42GF475K	5-27
R323		RESISTOR: Same as R322	5-27
R324		RESISTOR, VARIABLE: 5 megohms ±20%, 2 watts, composition, linear taper, high voltage insulated shaft; mfr 12697, part no. 53MV	5-13
R325		RESISTOR, Same as R153	5-27
R326		RESISTOR: MIL type RC32GF125K	5-27
R327		RESISTOR: Same as R102	5-27
R328		RESISTOR: MIL type RC20GF273K	5-27
R330		RESISTOR, VARIABLE: 1.2 megohms ±20%, 2 watts, composition, linear taper; mfr 12697, part no. 53M	5-13
R331		RESISTOR: Same as R313	5-27
R332		RESISTOR: Same as R156	5-27
R333		RESISTOR: Same as R313	5-27
R334		RESISTOR: Same as R312	5-27
R335		RESISTOR: MIL type RL42AD113J	5-26
R336		RESISTOR: Same as R144	5-26
R337		RESISTOR: Same as R1	5-26
R338		RESISTOR: Same as R156	5-26
R339		RESISTOR: Same as R1	5-26
R340		RESISTOR: Same as R156	5-26
R341		RESISTOR: MIL type RC20GF225K	5-25
R342		RESISTOR: Same as R335	5-26
R343		RESISTOR: MIL type RN70B2001F	5-25
R344		RESISTOR: Same as R233	5-25
R345		RESISTOR: MIL type RN70B6191F	5-25
R346		RESISTOR: MIL type RN70C2031D	5-25
R347		RESISTOR: MIL type RN70B1021F	5-25
R348		RESISTOR: MIL type RN70C5970D	5-25
R349		RESISTOR: MIL type RN70B2000F	5-25
R350		RESISTOR: MIL type RN70B1000F	5-25
R351		RESISTOR: MIL type RN70B60R4F	5-25
R352		RESISTOR: MIL type RN70B40R2F	5-25
R353		RESISTOR: MIL type RN70B2003F	5-25
R354		RESISTOR: Same as R349	5-25
R355		RESISTOR: Same as R41	5-27
R356		RESISTOR: Same as R328	5-27
R357		RESISTOR: Same as R341	5-27
R358		RESISTOR: MIL type RN70B4533F	5-27
R359		RESISTOR: MIL type RN70B4023F	5-27
R360		RESISTOR: MIL type RC32GF393K	5-27
R361		RESISTOR: Same as R163	5-9
R362		RESISTOR: MIL type RC32GF123K	5-27
R363		RESISTOR: MIL type RV4NAYSD503A	5-13
R364		RESISTOR: Same as R206	5-27

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REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R365		RESISTOR: Same as R362	5-27
R366		RESISTOR: MIL type RC32GF333K	5-27
R367		RESISTOR: MIL type RL42AD223J	5-25
R368		RESISTOR: MIL type RW59GR25	5-13
R400		RESISTOR: Same as R180	5-11
R401		RESISTOR: MIL type RC20GF393K	5-10
R402		RESISTOR: MIL type RC42GF683K	5-10
R403		RESISTOR: MIL type RW31G500	5-11
R405		RESISTOR: MIL type RW29V161	5-11
R406		RESISTOR: Same as R405	5-11
R407		RESISTOR: Same as R405	5-11
R408		RESISTOR, FIXED, FILM: Same as R109	5-29
R409		RESISTOR: Same as R188	5-29
R410		RESISTOR, FIXED, FILM: 20K ±5%, 5 watts, deposited metal film, glass body; mfr 07115, part no. LP15-203J	5-29
R411		RESISTOR: MIL type RV4LAYSA103A	5-10
R412		RESISTOR, FIXED, FILM: Same as R410	5-29
R413		RESISTOR: Same as R335	5-29
R415		RESISTOR: MIL type RL32AD134J	5-29
R416		RESISTOR: MIL type RL20AD511J	5-29
R417		RESISTOR: MIL type RC20GF330K	5-29
R421		RESISTOR: MIL type RW32W710	5-11
R422		RESISTOR: Same as R135	5-10
R423		RESISTOR: MIL type RC42GF330K	5-10
R424		RESISTOR: MIL type RW32V500	5-11
R425		RESISTOR: MIL type RL20AD111J	5-29
R426		RESISTOR: MIL type RC32GF273K	5-29
R427		RESISTOR: MIL type RW55G180	5-29
R428		RESISTOR: Same as R105	5-29
R429		RESISTOR: MIL type RL20AD823J	5-29
R430		RESISTOR: Same as R142	5-29
R431		RESISTOR: MIL type RV4LAYSA252A	5-10
R432		RESISTOR: MIL type RN70B5112F	5-29
R433		RESISTOR: MIL type RN70B9092F	5-29
R434		RESISTOR: Same as R98	5-29
R435		RESISTOR: Same as R416	5-29
R437		RESISTOR: MIL type RL20AD202J	5-29
R438		RESISTOR: Same as R405	5-11
R439		RESISTOR: MIL type RW55V120	5-11
R440		RESISTOR: Same as R135	5-10
R441		RESISTOR: Same As R423	5-10
R442		RESISTOR: MIL type RW29V121	5-11
R443		RESISTOR: Same as R23	5-29
R444		RESISTOR: MIL type RC32GF223K	5-29
R445		RESISTOR: MIL type RL42AD240J	5-29
R446		RESISTOR: MIL type RL42AD182J	5-29
R447		RESISTOR: MIL type RC20GF682K	5-29
R448		RESISTOR: Same as R426	5-29
R449		RESISTOR: MIL type RL20AD432J	5-29
R450		RESISTOR: Same as R5	5-29
R451		RESISTOR: MIL type RC20GF681K	5-29
R452		RESISTOR: Same as R211	5-11
R457		RESISTOR: Same as R423	5-9
R458		RESISTOR: MIL type RC42GF331K	5-10
R459		RESISTOR: Same as R273	5-29
R460		RESISTOR: MIL type RW24G1R5	5-12
R461		RESISTOR: MIL type RC32GF473K	5-29
R462		RESISTOR: Same as R23	5-29
R463		RESISTOR: Same as R1	5-29
R464		RESISTOR: MIL type RV4LAYSA251A	5-11

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R1001		RESISTOR: MIL type RC20GF335K	5-18
R1002		RESISTOR: Same as R178	5-10
R1003		RESISTOR: Same as R178	5-10
R1004		RESISTOR: Same as R178	5-10
R1005		RESISTOR: MIL type RC20GF564K	5-18
R1006		RESISTOR: Same as R168	5-18
R1007		RESISTOR: Same as R168	5-18
R1009		RESISTOR, VARIABLE: 50K ±20%, 1 watt, composition, linear taper; mfr 28480, part no. 2100-0215-9	5-11
R1010		RESISTOR: MIL type RC32GF183K	5-11
R1011		RESISTOR: MIL type RN80B3655F	5-18
R1012		RESISTOR: MIL type RN75B4534F	5-18
R1013		RESISTOR: Same as R1012	5-18
R1014		RESISTOR: MIL type RN75B3654F	5-18
R1015		RESISTOR: MIL type RN70B9093F	5-18
R1016		RESISTOR: Same as R1015	5-18
R1017		RESISTOR: MIL type RN70B3653F	5-18
R1018		RESISTOR: Same as R433	5-18
R1019		RESISTOR: Same as R433	5-18
R1020		RESISTOR: Same as R433	5-18
R1021		RESISTOR: Same as R107	5-18
R1023		RESISTOR: MIL type RC42GF470K	5-21
R1024		RESISTOR: Same as R178	5-10
R1025		RESISTOR: MIL type RA20NBSD500A	5-13
R1026		RESISTOR: Same as R1012	5-18
R1027		RESISTOR: Same as R1012	5-18
S1		SWITCH, PUSH: 4 pdt, momentary action; mfr 28480, part no. 3101-0024-9	5-13
S101		SWITCH, ROTARY: 1 section, 4 position, dual concentric shafts independently variable, includes R162; resistor, variable and S103; switch, rotary, not separately replaceable; mfr 28480, part no. 3100-0783-9	5-19
S102		SWITCH, ROTARY: 1 section, 2 position, dual concentric shafts, shafts independently variable, includes R105; resistor, variable, not separately replaceable; mfr 28480, part no. 3100-0782-9	5-20
S103		SWITCH, ROTARY: Part of S101, not separately replaceable.	5-19
S201		SWITCH: MIL type MS34058-22	5-13
S202		SWITCH, ROTARY: 5 sections, 16 positions; mfr 28480, part no. 3100-0781-9	5-21
S203		SWITCH: Part of R209, not separately replaceable	5-21
S302		SWITCH, ROTARY: 2 section, 11 position; mfr 28480, part no. 3100-0780-9	5-25
S401		SWITCH: MIL type MS35059-22	5-13
S402		SWITCH, THERMOSTATIC: SPDT, open 140°F ±5°, close 120°F ±5°, 25 amp-rating, 250 vdcw, screw terminals; mfr 82647, part no. 20400D/L140-2/4561-2	5-11
S1001		SWITCH, ROTARY: 5 section, 24 position; mfr 28480, part no. 3100-0779-9	5-18
S1002		SWITCH: Part of R1009, not separately replaceable	5-11
TB1		TERMINAL BOARD: 4 insulated terminals, two mounting terminals; mfr 06540, part no. DA1A1A1DA1	5-9
TB2		TERMINAL BOARD: 1 insulated terminal, 1 mounting terminal, DA1 pattern, epoxy glass; mfr 06540, part no. 610	5-10
TB201		TERMINAL BOARD: Same as TB2	5-21
TB301		TERMINAL BOARD: 3 insulated terminals, 1 grounding terminal, epoxy glass; mfr 06540, part no. 744	5-11
TB401		TERMINAL BOARD: Barrier block, 5 dual contacts with single screw per dual contact, brass, nickel plate contacts; mfr 75382, part no. 599M-ST-5	5-9
TB402		TERMINAL BOARD: Same as TB401	5-9
TB403		TERMINAL BOARD: Same as TB401	5-10

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
TB404		TERMINAL BOARD: Same as TB2	5-10
TB405		TERMINAL BOARD: 2 insulated terminals, 1 grounding terminal, A1GA1 pattern, epoxy glass; mfr 06540, part no. 669	5-12
TB406		TERMINAL BOARD: 4 insulated terminals, 1 grounding terminal, A1A1GA1A1 pattern, epoxy glass; mfr 06540, part no. 797	5-11
TB408		TERMINAL BOARD: Same as TB405	5-10
T301		TRANSFORMER, HIGH VOLTAGE:	5-9
T401		TRANSFORMER, POWER, STEP-DOWN AND STEP-UP: 5-1/4 in. high, 6 in. wide, 4-7/8 in. deep, sealed can type; mfr 98734, part no. 9463	5-9
V1		ELECTRON TUBE: MIL type 7308	5-6
V2		ELECTRON TUBE: Same as V1	5-6
V3		ELECTRON TUBE: Same as V1	5-6
V4		ELECTRON TUBE: Same as V1	5-6
V5		ELECTRON TUBE: Same as V1	5-6
V6		ELECTRON TUBE: Same as V1	5-6
V7		ELECTRON TUBE: Same as V1	5-6
V8		LAMP, GLOW: Same as DS402	5-15
V9		LAMP, GLOW: Same as DS402	5-15
V10		ELECTRON TUBE: Same as V1	5-6
V11		ELECTRON TUBE: Same as V1	5-6
V12		ELECTRON TUBE: Same as V1	5-6
V13		ELECTRON TUBE: Same as V1	5-6
V101		ELECTRON TUBE: Same as V1	5-6
V102		LAMP, GLOW: Same as DS402	5-17
V103		ELECTRON TUBE: Same as V1	5-6
V104		ELECTRON TUBE: Same as V1	5-6
V105		ELECTRON TUBE: Same as V1	5-6
V107		ELECTRON TUBE: Same as V1	5-6
V109		ELECTRON TUBE: JAN type 6CL6	5-6
V110		LAMP, GLOW: Same as DS402	5-17
V111		LAMP, GLOW: Same as DS402	5-17
V113		ELECTRON TUBE: Same as V1	5-6
V114		ELECTRON TUBE: Same as V1	5-6
V115		ELECTRON TUBE: Same as V1	5-6
V116		LAMP, GLOW: Same as DS402	5-17
V201		ELECTRON TUBE: Same as V1	5-6
V202		ELECTRON TUBE: Same as V1	5-6
V203		ELECTRON TUBE: Same as V1	5-6
V204		ELECTRON TUBE: Same as V109	5-6
V205		ELECTRON TUBE: Same as V109	5-6
V206		ELECTRON TUBE: Same as V1	5-6
V207		ELECTRON TUBE: Same as V109	5-6
V301		ELECTRON TUBE: Same as V1	5-6
V303		LAMP, GLOW: Same as DS402	5-26
V304		ELECTRON TUBE: JAN type 6005/6AQ5W	5-6
V305		ELECTRON TUBE: MIL type 5BHP2	5-6
V306		ELECTRON TUBE: Same as V1	5-6
V307		ELECTRON TUBE: JAN type 5726/6AL5W	5-6
V308		ELECTRON TUBE: MIL type 1X2B	5-6
V309		ELECTRON TUBE: Same as V308	5-6
V310		ELECTRON TUBE: Same as V308	5-6
V311		ELECTRON TUBE: Same as V308	5-6
V401		ELECTRON TUBE: MIL type 5651WA	5-6
W401	(Part of power cable assembly)	CABLE: MIL type CX-4704/U 98-1/2 in. lg	1-1

MAINTENANCE PARTS LIST

OSCILLOSCOPE OS-121B/USM-140

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
W605	(Part of cord CG-409E/U)	CABLE: MIL type RG-58C/U, 95-1/2 in. lg.	1-1
W606		CABLE: Same as W605	1-1
XDS401		LAMPHOLDER: MIL type LH74LC13RN	5-13
XDS403 through XDS406		LAMPHOLDER ASSY: 4 lampholders with connecting cables; mfr 28480, part no. 1450-0024-9	5-9
XDS1001		LAMPHOLDER: MIL type MS90282-3	5-13
XF401		FUSEHOLDER: MIL type FD-1	5-11
XF402		FUSEHOLDER: Same as XF401	5-11
XF403		FUSEHOLDER: Same as XF401	5-11
XF404		FUSEHOLDER: Same as XF401	5-10
XF405		FUSEHOLDER: Same as XF401	5-10
XF406		FUSEHOLDER: Same as XF401	5-11
XV1		SOCKET, ELECTRON TUBE: 9 pin miniature, plug-in type mounting for printed circuits, mica phenolic insulation, phosphor bronze tinned contacts; mfr 71785, part no. 121-51-11-060	5-14
XV2		SOCKET, ELECTRON TUBE: 9 pin miniature; uhf standoff type, mica filled phenolic insulation; phosphor bronze silver plated contacts; mfr 04156, part no. 3901PHSPTD	5-14
XV3		SOCKET, ELECTRON TUBE: Same as XV2	5-14
XV4		SOCKET, ELECTRON TUBE: Same as XV1	5-14
XV5		SOCKET, ELECTRON TUBE: Same as XV1	5-14
XV6		SOCKET, ELECTRON TUBE: Same as XV2	5-15
XV7		SOCKET, ELECTRON TUBE: Same as XV1	5-15
XV10		SOCKET, ELECTRON TUBE: Same as XV1	5-15
XV11		SOCKET, ELECTRON TUBE: Same as XV1	5-15
XV12		SOCKET, ELECTRON TUBE: Same as XV2	5-15
XV13		SOCKET, ELECTRON TUBE: Same as XV2	5-15
XV101		SOCKET, ELECTRON TUBE: Same as XV1	5-17
XV103		SOCKET, ELECTRON TUBE: Same as XV1	5-17
XV104		SOCKET, ELECTRON TUBE: Same as XV1	5-17
XV105		SOCKET, ELECTRON TUBE: Same as XV1	5-17
XV107		SOCKET, ELECTRON TUBE: Same as XV1	5-17
XV109		SOCKET, ELECTRON TUBE: Same as XV1	5-17
XV113		SOCKET, ELECTRON TUBE: Same as XV1	5-17
XV114		SOCKET, ELECTRON TUBE: Same as AV1	5-17
XV115		SOCKET, ELECTRON TUBE: Same as XV1	5-17
XV201		SOCKET, ELECTRON TUBE: Same as XV1	5-24
XV202		SOCKET, ELECTRON TUBE: Same as XV1	5-24
XV203		SOCKET, ELECTRON TUBE: Same as XV1	5-23
XV204		SOCKET, ELECTRON TUBE: Same as XV1	5-23
XV205		SOCKET, ELECTRON TUBE: Same as XV1	5-23
XV206		SOCKET, ELECTRON TUBE: Same as XV1	5-23
XV207		SOCKET, ELECTRON TUBE: Same as XV1	5-23
XV301		SOCKET, ELECTRON TUBE: Same as XV1	5-26
XV304		SOCKET, ELECTRON TUBE: 7 pin miniature type, plug-in type mounting for printed circuits, mica phenolic insulation, phosphor bronze tinned contacts; mfr 71785, part no. 111-51-11-069	5-26
XV305		SOCKET, ELECTRON TUBE: 14 slots equally spaced, molded mica filled phenolic; mfr 72825, part no. 9709-4	5-9
XV306		SOCKET, ELECTRON TUBE: Same as XV1	5-26
XV307		SOCKET, ELECTRON TUBE: Same as XV304	5-26
XV308		SOCKET, ELECTRON TUBE: 9 pin miniature, mica filled phenolic; mfr 95354, part no. SMJ-799	5-26
XV309		SOCKET, ELECTRON TUBE: Same as XV308	5-26
XV310		SOCKET, ELECTRON TUBE: Same as XV1	5-26
XV311		SOCKET, ELECTRON TUBE: Same as XV1	5-26
XV401		SOCKET, ELECTRON TUBE: Same as XV304	5-29

MAINTENANCE PARTS LIST

OSCILLOSCOPE SUBASSEMBLY, VERTICAL CHANNEL DUAL TRACE PREAMPLIFIER MX-2930B/USM

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
A1 through A499		Not Used	
A500		VERTICAL PRESENTATION SWITCH ASSEMBLY: Selector switch with additional components as shown schematically in figure 5-46; mfr 28480, P/N 162A-19D(N)	5-34
A501		MX-2930B/USM DUAL CHANNEL VERTICAL AMPLIFIER ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-46; mfr 28480, P/N 162A-65E(N)	5-31
A502		MX-2930B/USM VERTICAL SWITCHING ETCHED CIRCUIT ASSEMBLY: Circuit board with all components as shown schematically in figure 5-46; mfr 28480, P/N 162A-65F(N)	5-32
A503		VERNIER/SENSITIVITY SWITCH ASSEMBLY: Selector switch and potentiometer assembly with additional components as shown schematically in figure 5-46; mfr 28480, P/N 162A-34C(N)	5-33
CR501		SEMICONDUCTOR DEVICE, DIODE: Same as CR102	5-31
CR502		SEMICONDUCTOR DEVICE, DIODE: Same as CR102	5-32
CR503		SEMICONDUCTOR DEVICE, DIODE: Same as CR102	5-32
CR504		SEMICONDUCTOR DEVICE, DIODE: Same as CR102	5-32
CR505		SEMICONDUCTOR DEVICE, DIODE: Same as CR102	5-31
CR506		DIODE: MIL type 1N979B	5-32
C503		CAPACITOR: Same as C1	5-31
C504		CAPACITOR: Same as C1	5-31
C506		CAPACITOR: Same as C1	5-32
C507		CAPACITOR: Same as C1	5-32
C508		CAPACITOR: Same as C1	5-32
C509		CAPACITOR: Same as C31	5-32
C510		CAPACITOR: Same as C31	5-32
C511		CAPACITOR: Same as C1	5-32
C515		CAPACITOR: Same as C1	5-32
C516		CAPACITOR: Same as C1	5-31
C517		CAPACITOR: MIL type CPO5A1KB104K3	5-31
C518		CAPACITOR: Same as C517	5-31
C519		CAPACITOR: Same as C1	5-32
C522		CAPACITOR: Same as C103	5-31
C523		CAPACITOR: Same as C103	5-31
C1501		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C202	5-33
C1502		CAPACITOR, FIXED, PLASTIC DIELECTRIC: Same as C202	5-33
C1503		CAPACITOR: MIL type CC20CH200G	5-33
C1504		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1505		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1506		CAPACITOR: MIL type CC20CH100C	5-33
C1507		CAPACITOR: Same as C1506	5-33
C1508		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1509		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1510		CAPACITOR: Same as C314	5-33
C1511		CAPACITOR: MIL type CC20CH050C	5-33
C1512		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1513		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33

MAINTENANCE PARTS LIST

OSCILLOSCOPE SUBASSEMBLY, VERTICAL CHANNEL DUAL TRACE PREAMPLIFIER MX-2930B/USM

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
C1514		CAPACITOR: Same as C1511	5-33
C1515		CAPACITOR: MIL type CM15C390JN3	5-33
C1516		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1517		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1518		CAPACITOR: Same as C1506	5-33
C1519		CAPACITOR: Same as C1515	5-33
C1520		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1521		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1522		CAPACITOR: Same as C1506	5-33
C1523		CAPACITOR: Same as C114	5-33
C1524		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1525		CAPACITOR: Same as C1506	5-33
C1526		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1527		CAPACITOR: MIL type CB11RD221J	5-33
C1528		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1529		CAPACITOR: Same as C1506	5-33
C1530		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1531		CAPACITOR: MIL type CB11RD471J	5-33
C1532		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1533		CAPACITOR: Same as C1506	5-33
C1534		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1535		CAPACITOR: MIL type CB11RD102J	5-33
C1536		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1537		CAPACITOR: Same as C1506	5-33
C1538		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1539		CAPACITOR, FIXED, MICA DIELECTRIC: 2000 $\mu\mu$f ±5%, 500 vdcw, 350 vacw; mfr 28480, part no. 0140-0131-9	5-33
C1540		CAPACITOR: Same as C110	5-33
C1541		CAPACITOR: Same as C110	5-33
C1544		CAPACITOR: Same as C110	5-33
C1545		CAPACITOR: Same as C110	5-33
C1546		CAPACITOR: Same as C1503	5-33
C1547		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1548		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1549		CAPACITOR: Same as C1506	5-33
C1550		CAPACITOR: Same as C1506	5-33
C1551		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1552		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1553		CAPACITOR: Same as C314	5-33
C1554		CAPACITOR: Same as C1511	5-33
C1555		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1556		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1557		CAPACITOR: Same as C1511	5-33
C1558		CAPACITOR: Same as C1515	5-33
C1559		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1560		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1561		CAPACITOR: Same as C1506	5-33
C1562		CAPACITOR: Same as C1515	5-33
C1563		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1564		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1565		CAPACITOR: Same as C1506	5-33
C1566		CAPACITOR: Same as C114	5-33
C1567		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1568		CAPACITOR: Same as C1506	5-33
C1569		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1570		CAPACITOR: Same as C1527	5-33

MAINTENANCE PARTS LIST

OSCILLOSCOPE SUBASSEMBLY, VERTICAL CHANNEL DUAL TRACE PREAMPLIFIER MX-2930B/USM

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
C1571		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1572		CAPACITOR: Same as C1506	5-33
C1573		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1574		CAPACITOR: Same as C1531	5-33
C1575		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1576		CAPACITOR: Same as C1506	5-33
C1577		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1578		CAPACITOR: Same as C1535	5-33
C1579		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1580		CAPACITOR: Same as C1506	5-33
C1581		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1582		CAPACITOR, FIXED, MICA DIELECTRIC: Same as C1539	5-33
C1587		CAPACITOR: Same as C110	5-34
C1588		CAPACITOR: Same as C303	5-33
C1589		CAPACITOR: MIL type CC20CH8R2C	5-33
C1590		CAPACITOR, VARIABLE, PLASTIC: Same as C20	5-33
C1591		CAPACITOR: Same as C303	5-34
C1592		CAPACITOR, VARIABLE, PLASTIC: 0.7 $\mu\mu$f min., 3.0 $\mu\mu$f max., 350 vdcw, piston type, screwdriver adjustment, ribbon leads; mfr 72982, part no. 535-033 4R	5-34
C1593		CAPACITOR: Same as C1	5-34
C1594		CAPACITOR, VARIABLE, PLASTIC: Same as C1592	5-34
C1595		CAPACITOR: Same as C303	5-33
J501		CONNECTOR: Same as J101	5-30
J502		CONNECTOR: Same as J101	5-30
L501		COIL, RADIO FREQUENCY: 1.55-2.6 μh, operating frequency 30 mc, on ceramic form 3/16 in. diameter by 15/16 in. over-all length; mfr 28480, part no. 9140-0048-9	5-31
L502		COIL, RADIO FREQUENCY: Same as L501	5-31
L503		COIL: MIL type MS16222-9	5-31
L505		COIL: Same as L503	5-31
L508		COIL: Same as L503	5-31
L510		COIL: Same as L503	5-31
L511		COIL, RADIO FREQUENCY: Same as L501	5-31
L512		COIL, RADIO FREQUENCY: Same as L501	5-31
L513		COIL: Same as L301	5-32
L514		COIL: Same as L3	5-31
L515		COIL: Same as L3	5-31
L516		COIL: MIL type MS75008-3	5-31
L517		COIL: Same as L516	5-31
L518		COIL: Same as L3	5-31
L519		COIL: Same as L3	5-31
MP501		TERMINAL POST:	5-30
MP502		TERMINAL POST: Same as MP501	5-30
MP503		BUSHING, SLEEVE:	5-30
MP504		BUSHING, SLEEVE: Same as MP503	5-30
MP505		KNOB: 1-5/8 in. dia., fits 3/16 in. dia. shaft, 2 setscrews, black phenolic with non-removable brass core; mfr 28480, part no. 0370-0037-9	5-30
MP506		KNOB: Same as MP505	5-30
MP507		KNOB: 3/4 in. dia., fits 3/16 in. dia. shaft, 2 setscrews, red phenolic with removable brass core; mfr 28480, part no. 0370-0061-9	5-30
MP508		KNOB: Same as MP507	5-30
MP509		KNOB: 3/4 in. dia., fits 1/4 in. dia. shaft, 2 setscrews, red phenolic with non-removable brass core; mfr 28480, part no. 0370-0062-9	5-30

MAINTENANCE PARTS LIST

OSCILLOSCOPE SUBASSEMBLY, VERTICAL CHANNEL DUAL TRACE PREAMPLIFIER MX-2930B/USM

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
MP510		KNOB: Same as MP509	5-30
MP511		KNOB: 1 in. dia., fits 1/4 in. dia. shaft 2 setscrews, black plastic, molded, with non-removable brass core; mfr 28480, part no. 0370-0067-9	5-30
MP512		KNOB: Same as MP511	5-30
MP513		KNOB: 1-5/16 in. dia., 2 setscrews, black phenolic with non-removable brass core; mfr 28480, part no. 0370-0077-9	5-30
MP514		KNOB: 45/64 in. dia., fits 1/4 in. dia shaft, 2 setscrews, black phenolic with non-removable brass core; mfr 28480, part no. 0370-0084-9	5-30
MP515		KNOB: Same as MP514	5-30
MP516		KNOB: 5/8 in. dia., 2 setscrews, black phenolic, with non-removable brass core; mfr 28480, part no. 0370-0088-9	5-30
MP517		SHIELD: JAN type TS103U02	5-30
MP518		SHIELD: Same as MP517	5-30
MP519		LATCH, FASTENER: 0-1/4 in. grip, less knob, adjustable pawl, clockwise locking; mfr 91079, part no. 48-10-321-10	5-30
MP520		BUSHING, MACHINE THREAD: 3/8-32 NEF-2A thread, nickel plated; mfr 28480, part no. 1410-0052-9	5-30
MP521		BUSHING, MACHINE THREAD: Same as MP520	5-30
MP522		BUSHING, MACHINE THREAD: Same as MP520	5-30
MP523		BUSHING, MACHINE THREAD: Same as MP520	5-30
MP524		MOUNT, RESILIENT: 3/4 in. dia., elastomer isolation material, aluminum alloy spacer; mfr 76005, part no. J-8483-6	5-30
MP525		MOUNT, RESILIENT: Same as MP524	5-30
MP526		MOUNT, RESILIENT: Same as MP524	5-30
MP527		MOUNT, RESILIENT: Same as MP524	5-30
P501		CONNECTOR, RECEPTACLE, ELECTRICAL: 16 contacts, flat type, molded plastic body; mfr 02660, part no. 26-5100-16P	5-30
Q501		TRANSISTOR: Same as Q201	5-31
Q502		TRANSISTOR: Same as Q201	5-31
Q503		TRANSISTOR: Same as Q201	5-31
Q504		TRANSISTOR: Same as Q201	5-31
R501		RESISTOR: Same as R444	5-31
R502		RESISTOR: Same as R444	5-31
R503		RESISTOR: MIL type RC07GF560K	5-31
R504		RESISTOR: MIL type RV4NAYSD502A	5-30
R505		RESISTOR: Same as R503	5-31
R507		RESISTOR: Same as R89	5-31
R508		RESISTOR: MIL type RV4NAYSD252A	5-30
R509		RESISTOR: Same as R89	5-31
R510 A/B		RESISTOR, VARIABLE: Dual section, 250 ohms ±20%, 2 watts each section, includes dpst switch; mfr 01121, part no. JJ90120	5-31
R512		RESISTOR: MIL type RL20AD303J	5-31
R513		RESISTOR: Same as R512	5-31
R514		RESISTOR: Same as R180	5-31
R515		RESISTOR: Same as R158	5-31
R516		RESISTOR: MIL type RN60B1301F	5-31
R517		RESISTOR: Same as R516	5-31
R518		RESISTOR: MIL type RN65B1502F	5-31
R519		RESISTOR: Same as R89	5-31
R520		RESISTOR, VARIABLE: Part of S506, not separately replaceable	
R521		RESISTOR: Same as R89	5-31
R522		RESISTOR: Same as R518	5-31
R523		RESISTOR: MIL type RN75B4991F	5-31
R524		RESISTOR: Same as R523	5-31
R525		RESISTOR: Same as R78	5-31

MAINTENANCE PARTS LIST

OSCILLOSCOPE SUBASSEMBLY, VERTICAL CHANNEL DUAL TRACE PREAMPLIFIER MX-2930B/USM

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R526		RESISTOR: Same as R180	5-32
R527		RESISTOR: Same as R503	5-31
R528		RESISTOR: Same as R503	5-31
R529		RESISTOR, FIXED, FILM: Same as R89	5-31
R530		RESISTOR, VARIABLE: Part of S507, not separately replaceable	
R531		RESISTOR, FIXED, FILM: Same as R89	5-31
R532		RESISTOR: Same as R518	5-31
R533		RESISTOR: Same as R518	5-31
R534		RESISTOR: Same as R516	5-31
R535		RESISTOR: Same as R516	5-31
R536		RESISTOR: Same as R158	5-31
R537		RESISTOR: Same as R180	5-31
R538		RESISTOR: Same as R512	5-31
R539		RESISTOR: Same as R512	5-31
R540A/B		RESISTOR, VARIABLE: Same as R510A/B	5-33
R542		RESISTOR, FIXED, FILM: Same as R89	5-31
R543		RESISTOR: Same as R508	5-30
R544		RESISTOR, FIXED, FILM: Same as R89	5-31
R545		RESISTOR: Same as R503	5-31
R546		RESISTOR: Same as R504	5-30
R547		RESISTOR: Same as R503	5-31
R548		RESISTOR: Same as R444	5-31
R549		RESISTOR: Same as R444	5-31
R550		RESISTOR: Same as R503	5-31
R551		RESISTOR: Same as R503	5-31
R552		RESISTOR: MIL type RL42AD202J	5-31
R553		RESISTOR: MIL type RC07GF182K	5-34
R554		RESISTOR: Same as R503	5-32
R555		RESISTOR: Same as R88	5-32
R556		RESISTOR, FIXED, FILM: Same as R109	5-32
R557		RESISTOR: Same as R159	5-32
R558		RESISTOR: Same as R503	5-32
R559		RESISTOR: Same as R2	5-32
R560		RESISTOR: Same as R254	5-32
R561		RESISTOR: MIL type RC07GF152K	5-34
R562		RESISTOR: Same as R20	5-32
R563		RESISTOR: MIL type RN70B1823F	5-32
R564		RESISTOR: Same as R503	5-32
R565		RESISTOR: Same as R563	5-32
R566		RESISTOR: Same as R563	5-32
R567		RESISTOR: Same as R503	5-32
R568		RESISTOR: Same as R563	5-32
R569		RESISTOR: Same as R20	5-32
R570		RESISTOR: MIL type RL42AD392J	5-32
R571		RESISTOR: MIL type RC07GF222K	5-31
R572		RESISTOR: Same as R571	5-31
R573		RESISTOR: Same as R571	5-31
R574		RESISTOR: Same as R571	5-31
R575		RESISTOR: MIL type RW55GR471	5-31
R576		RESISTOR: Same as R78	5-31
R579		RESISTOR: Same as R29	5-32
R580		RESISTOR: MIL type RC20GF392K	5-31
R581		RESISTOR: Same as R580	5-31
R582		RESISTOR: MIL type RC07GF680K	5-31
R583		RESISTOR: Same as R582	5-31
R584		RESISTOR: Same as R523	5-31

MAINTENANCE PARTS LIST

OSCILLOSCOPE SUBASSEMBLY, VERTICAL CHANNEL DUAL TRACE PREAMPLIFIER MX-2930B/USM

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R585		RESISTOR: Same as R523	5-31
R586		RESISTOR: Same as R8	5-31
R587		RESISTOR: Same as R8	5-31
R588		RESISTOR: Same as R582	5-31
R589		RESISTOR: Same as R582	5-31
R590		RESISTOR: MIL type RW32G103	5-33
R591		RESISTOR: MIL type RC20GF182K	5-32
R592		RESISTOR: Same as R591	5-32
R593		RESISTOR: Same as R8	5-32
R1500		RESISTOR: Same as R503	5-33
R1501		RESISTOR: MIL type RN65B6043F	5-33
R1502		RESISTOR: MIL type RN65B6653F	5-33
R1503		RESISTOR: MIL type RN65C7963D	5-33
R1504		RESISTOR: MIL type RN65B2493F	5-33
R1505		RESISTOR: Same as R203	5-33
R1506		RESISTOR: Same as R204	5-33
R1507		RESISTOR: MIL type RN65B9533F	5-33
R1508		RESISTOR: MIL type RN65B4122F	5-33
R1509		RESISTOR: MIL type RN65B9763F	5-33
R1510		RESISTOR: MIL type RN65C2032D	5-33
R1511		RESISTOR: Same as R205	5-33
R1512		RESISTOR: Same as R78	5-33
R1513		RESISTOR: MIL type RN65B1022F	5-33
R1514		RESISTOR: Same as R205	5-33
R1515		RESISTOR: Same as R78	5-33
R1516		RESISTOR: MIL type RN65B4021F	5-33
R1517		RESISTOR: Same as R205	5-33
R1518		RESISTOR: Same as R78	5-33
R1519		RESISTOR: MIL type RN65B2001F	5-33
R1520		RESISTOR: Same as R205	5-33
R1521		RESISTOR: Same as R107	5-33
R1522		RESISTOR, FIXED, COMPOSITION: 4.7 ohm ±5%, 1/2 watt, composition; mfr 01121, part no. EB47G5	5-33
R1523		RESISTOR: MIL type RN65B1001F	5-33
R1524		RESISTOR: Same as R205	5-33
R1530		RESISTOR: Same as R503	5-33
R1531		RESISTOR: Same as R1501	5-33
R1532		RESISTOR: Same as R1502	5-33
R1533		RESISTOR: Same as R1503	5-33
R1534		RESISTOR: Same as R1504	5-33
R1535		RESISTOR: Same as R203	5-33
R1536		RESISTOR: Same as R204	5-33
R1537		RESISTOR: Same as R1507	5-33
R1538		RESISTOR: Same as R1508	5-33
R1539		RESISTOR: Same as R1509	5-33
R1540		RESISTOR: Same as R1510	5-33
R1541		RESISTOR: Same as R205	5-33
R1542		RESISTOR: Same as R78	5-33
R1543		RESISTOR: Same as R1513	5-33
R1544		RESISTOR: Same as R205	5-33
R1545		RESISTOR: Same as R78	5-33
R1546		RESISTOR: Same as R1516	5-33
R1547		RESISTOR: Same as R205	5-33
R1548		RESISTOR: Same as R78	5-33
R1549		RESISTOR: Same as R1519	5-33
R1550		RESISTOR: Same as R205	5-33

MAINTENANCE PARTS LIST

OSCILLOSCOPE SUBASSEMBLY, VERTICAL CHANNEL DUAL TRACE PREAMPLIFIER MX-2930B/USM

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
R1551		RESISTOR: Same as R107	5-34
R1552		RESISTOR, FIXED, COMPOSITION: Same as R1522	5-34
R1553		RESISTOR: Same as R1523	5-34
R1560		RESISTOR: Same as R205	5-34
R1561		RESISTOR: Same as R2	5-34
R1563		RESISTOR: Same as R2	5-34
R1564		RESISTOR: Same as R156	5-34
R1568		RESISTOR: Same as R156	5-34
S501		SWITCH, ROTARY: 1 section, 1 pole, 2 positions; mfr 71590, part no. PA200	5-33
S502		SWITCH, ROTARY: 3 sections, 12 positions, dual concentric shafts, shafts independently variable; mfr 28480, part no. 3100-0784-9	5-34
S503		SWITCH, ROTARY: Same as S501	5-33
S504		SWITCH, ROTARY: Same as S502	5-33
S505		SWITCH, ROTARY: 4 sections, 5 positions, dual concentric shafts, shafts independently variable; mfr 28480, part no. 3100-0785-9	5-34
S506		SWITCH, ROTARY: 2 sections, 2 positions, dual concentric shafts, shafts independently variable, includes R520, resistor, variable, not separately replaceable; mfr 28480, part no. 3100-0786-9	5-30
S507		SWITCH, ROTARY: Same as S506	5-30
T501		TRANSFORMER:	5-33
XV501		SOCKET, ELECTRON TUBE: 9 pin miniature, plug-in type mounting, mica phenolic insulation, phosphor bronze tinned contacts; mfr 71785, part no. 121-51-11-060	5-31
XV502		SOCKET, ELECTRON TUBE: Same as XV501	5-31
XV503		SOCKET, ELECTRON TUBE: 9 pin miniature UHF stand-off type, mica phenolic insulation, phosphor bronze tinned contacts; mfr 04156, part no. 3901PHSPTD	5-31
XV504		SOCKET, ELECTRON TUBE: Same as XV501	5-31
XV505		SOCKET, ELECTRON TUBE: Same as XV501	5-31
XV506		SOCKET, ELECTRON TUBE: Same as XV503	5-31
XV507		SOCKET, ELECTRON TUBE: 9 pin miniature type, shield base mounts for printed circuit board, mica phenolic insulation, phosphor bronze tinned contacts; mfr 71785, part no. 121-51-11-124	5-32
XV508		SOCKET, ELECTRON TUBE: Same as XV507	5-32
V501		ELECTRON TUBE: Same as V1	5-6
V502		ELECTRON TUBE: Same as V1	5-6
V503		ELECTRON TUBE: Same as V1	5-6
V504		ELECTRON TUBE: Same as V1	5-6
V505		ELECTRON TUBE: Same as V1	5-6
V506		ELECTRON TUBE: Same as V1	5-6
V507		ELECTRON TUBE: Same as V1	5-6
V508		ELECTRON TUBE: Same as V1	5-6
V509		LAMP, GLOW: Same as DS402	5-32

OSCILLOSCOPE SUBASSEMBLY, HORIZONTAL CHANNEL AUXILIARY PLUG-IN UNIT MX-3078/USM

CR2001		DIODE: Same as CR102	5-36
C2001		CAPACITOR: Same as C1	5-36
DS2001		LAMP: Same as DS401	5-36
E2001		COVER: Same as E101	5-36
E2002		COVER: Same as E101	5-36
J2001		CONNECTOR: Same as J101	5-36
J2002		CONNECTOR: Same as J101	5-36

MAINTENANCE PARTS LIST

OSCILLOSCOPE SUBASSEMBLY, HORIZONTAL CHANNEL AUXILIARY PLUG-IN UNIT MX-3078/USM

REF DESIG	NOTES	NAME AND DESCRIPTION	FIG. NO.
MP2001		KNOB: Same as MP516	5-36
MP2002		LATCH, FASTENER: 0-1/4inch grip, less knob, adjustable pawl, counterclockwise locking; mfr 91079, part no. 48-20-321-10	5-36
P2001		CONNECTOR, RECEPTACLE, ELECTRICAL: 32 contacts, flat type, molded plastic; mfr 02660, part no. 26-5100-32P	5-36
R2001		RESISTOR: Same as R2	5-36
S2001		SWITCH: MIL type MS35058-23	5-36
S2002		SWITCH: MIL type MS35059-23	5-36
TB2001		TERMINAL BOARD: Same as TB406	5-36
XDS2001		LAMPHOLDER: Same as XDS401	5-36

TEST PROD MX-2817/U

A601		TEST PROD: MX-2817/U, red; mfr 28480, P/N 10001A(N)	5-35
A602		TEST PROD: MX-2817/U, black; mfr 28480, P/N 10001C(N)	5-35
E601 and E602		PROBE JAW: Identical on both red and black probes	5-35
E603 and E604		PROBE BODY: Identical on both red and black probes	5-35
MP612 and MP613		CINCH NUT: Identical on both red and black probes	5-35
W601		PROBE CABLE: Assembly of coaxial cable with red boots at each end, terminated in BNC connector at one end and probe rear connector at other end	5-35
W602		PROBE CABLE: Assembly of coaxial cable with black boots at each end, terminated in BNC connector at one end and probe rear connector at other end	5-35
W603 and W604		GROUND CABLE: Assembly of black cable with alligator clip on one end and special mating connector for probe ground connection at other end. Identical for each probe	5-35

TOOLS SUPPLIED WITH OSCILLOSCOPE OS-121B/USM-140

MP610		KEY, SOCKET HEAD SCREW: L shaped, allen type, cap screws, cadmium plated; mfr 28480, part no. 1470-0004-9	5-12
MP611		KEY, SOCKET HEAD SCREW: L shaped, allen type, cap screws, cadmium plated; mfr 84396, part no. 18X	5-12

TABLE 6-3. LIST OF MANUFACTURERS

MFR CODE	NAME	ADDRESS
00866	Goe Engineering Co.	Los Angeles, Calif.
01121	Allen-Bradley Co.	Milwaukee, Wis.
01295	Texas Instruments Inc., Component Products Division	Dallas, Tex.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Broadview, Chicago, Ill.
04156	Elco Mfg. Co.	Berkeley, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N. Y.
07115	Corning Glass Works, Electronic Components Department	Bradford, Pa.
11237	Chicago Telephone of California Inc.	South Pasadena, Calif.
12697	Clarostat Mfg. Co. Inc.	Dover, N. H.
24455	Lamp Division of Consumer Products Group	GECO
28480	Hewlett-Packard Co.	Palo Alto, Calif.
56289	Sprague Electric Co.	North Adams, Mass.
62119	Universal Electric Co.	Owosso, Mich.
71590	Centralab Division of Globe-Union Inc.	Milwaukee, Wis.
71785	Cinch Mfg. Co., Division of United-Carr Fastener Corp.	Chicago, Ill.
72825	Eby, Hugh H., Inc.	Philadelphia, Pa.
72982	Erie Resistor Corp.	Erie, Pa.
75382	Kulka Electric Corp.	Mt. Vernon, N. Y.
76005	Lord Mfg. Co.	Erie, Pa.
81349	Military Specifications	
81350	Joint Army-Navy Specifications	
82647	Metals and Controls Inc., Spencer Products	Attleboro, Mass.
84396	Glesener, A. J., Co. Inc.	San Francisco, Calif.
91079	South Chester Corp.	Chester, Pa.
91418	Radio Materials Co.	Chicago, Ill.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products Inc.	Chicago, Ill.
95265	National Coil Co.	Sheridan, Wyo.
95354	Methode Manufacturing Co.	Chicago, Ill.
96733	San Fernando Electric Mfg. Co.	San Fernando, Calif.
96906	Military Standards	
98003	Nielsen Hardware Corp.	Hartford, Conn.
98734	Palo Alto Engineering Co. Inc.	Palo Alto, Calif.

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